CIVIL ENGINEERING

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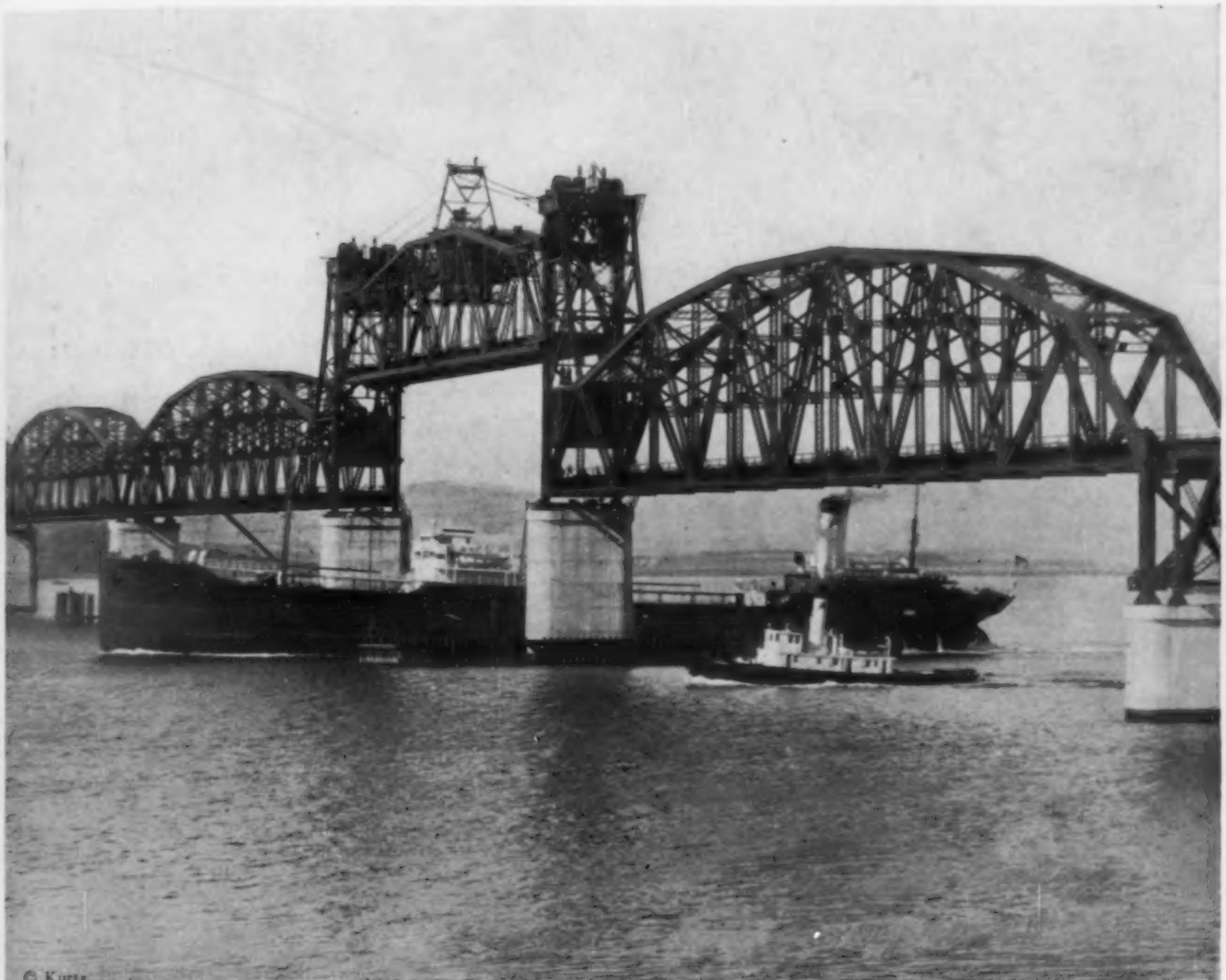


SUISUN BAY BRIDGE—SOUTHERN PACIFIC RAILROAD—SAN FRANCISCO

Volume 1 — AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 — Number 7

APRIL 1931

"Put it up to

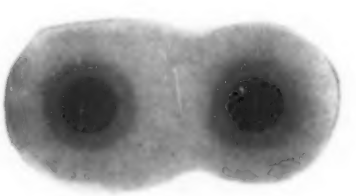
MacARTHUR"

These diagrams illustrate the reasons why MacArthur Piles, even when driven on close centers, are perfect piles.

(A) (B)

(A) Completed pile, formed by compressing a workable, dry mix concrete under 7 tons pressure. This forces dense concrete into intimate contact with surrounding soil, giving the maximum skin friction. Shading shows relative compression of soil due to driving and compression.

(B) Pile in process of being driven. Steel shell and core displacing and compacting surrounding soil.



Showing line of flow of soil. Soil displaced by pile in process of being driven follows the line of least resistance, which is away from the densely compacted soil surrounding the finished pile.

"TOUGH" jobs, that nobody else wanted, were given to us; completing them successfully built our reputation. Repeat orders from companies for whom we had done the "tough" jobs, built our business.

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Equipment . . latest	Clientele . illustrious	Speed . record-making

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The Greater Objective
of the
Engineering Profession

WITH what objective does the engineer serve his country, in peace and in war...? He builds our bridges, highways, and railroads; our motors, engines, and power plants. He makes nature herself a bondservant of humanity; and conquers the air, the land, and the sea; and all but annihilates time and space. To what end are these accomplishments directed?...underlying all of them is the motive that through them the reach of life may be enlarged; that mankind may be brought close together, and confidence and peace supplant suspicion, ignorance, and war. In other words, the lofty aim which inspires the work of the engineer is to transmute the forces and materials of nature into a spiritual power house, dedicated to the service of humanity....

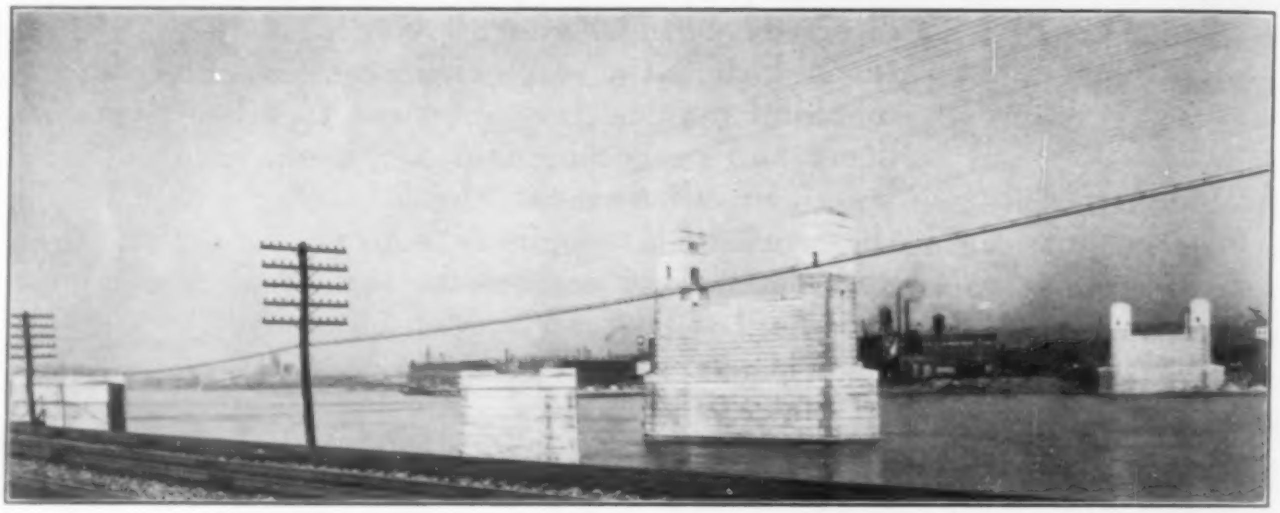
* * * * *

As engineers, therefore, our task is to serve our generation by making this world a still better place in which to live; in fact, to create a new world—an engineer's world, if you will, to be composed of steadily increasing varieties of engineering units, by means of which the life of humanity shall be knit together into a spiritual garment, of many colors to be sure, but seamless, and destined to cloak the valleys and mantle the hills of our universe.

JOHN H. DUNLAP

Extracted from an address delivered June 1, 1922, before the Rotary Club of Iowa City, Iowa. Mr. Dunlap, at that time Professor of Hydraulics and Sanitary Engineering at the State University of Iowa, was later elected Secretary of the American Society of Civil Engineers. While returning from a Society meeting in Pasadena, he was injured in a train wreck and died July 29, 1924.

CAISSON INSTALLATION—PIERS—SEPTEMBER 2, 1930



COMPLETED PIERS—JANUARY 30, 1931

Among Our Writers

Otis E. Hovey, who has been with the American Bridge Company for over 30 years, is the author of a two-volume book, entitled *Movable Bridges*. Mr. Hovey has been prominently identified with Society affairs.

F. R. McMillan was engaged in concrete research and in teaching structural engineering at the University of Minnesota for a number of years. Later he was Research Engineer on concrete ships for the U.S. Shipping Board.

Howard F. Peckworth, who graduated from Princeton in 1926, has since that time been connected with the construction of various sections of the new Eighth Avenue Subway of the Interborough Rapid Transit System of New York.

S. A. Thoresen, who was born in Norway and educated in Germany, started his engineering career in this country at the beginning of the century. He has been in charge of the design of subway, tunnel, canal, and hydro-electric projects in New York and Chicago.

C. H. Birdseye, during his 20 years of service with the U.S. Geological Survey, explored and mapped numerous inaccessible portions of the United States and Hawaii. He led an expedition by boat through the Grand Canyon of the Colorado River in 1923.

Thaddeus Merriman, in his quarter of a century of service with the Board of Water Supply of the City of New York, has, as Chief Engineer, designed and constructed the Catskill Water Supply System. He is a lecturer on hydraulics and water supply at Lehigh University and a recognized authority on municipal water supply.

C. E. Grunsky, Past-President of the Society, has for 50 years served his native state of California in many engineering capacities. His specialties are rate cases and irrigation, sewerage, and drainage problems.

J. H. Gandolfo is experienced in the construction of subways, tunnels, and steam, hydro-electric, and industrial plants. He was associated for several years with the Division of Architecture and Construction of the State of New Jersey.

S. F. Ferguson has for 25 years been designing and constructing roads and streets. Since 1926 he has been with the Kentucky Rock Asphalt Company.

Arthur Richards has, during the past 30 years, been widely engaged as consulting engineer on sanitary, hydraulic, and municipal engineering projects. He also served for six years with the Isthmian Canal Commission at Panama.

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VOLUME 1 APRIL 1931 NUMBER 7

Movable Bridges

Their Characteristics, Adaptability, Relative Economy, Design Methods, and Operation

By OTIS E. HOVEY
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
ASSISTANT CHIEF ENGINEER, AMERICAN BRIDGE COMPANY, NEW YORK, N.Y.

WHEREVER navigable streams must be crossed by bridges, it is necessary that the structures be built high enough to clear the traffic or be so designed that they can be opened or lifted beyond interference with the passage of boats. In the following article, based on a lecture delivered at the Summer School for Engineering Teachers at Yale University, July 17, 1930, Mr. Hovey points out the more usual types of movable bridges in use, their comparative cost and operating peculiarities, and comments on a few of the many problems of their design. His many years of experience in this work make the article one of unusual value.

ORIGINALLY the field of civil engineering included all branches of the profession except that which was strictly military in purpose. The great development and variety of engineering work have made it convenient to think of most projects as pertaining to one or another of the broad subdivisions of civil, mining, mechanical, electrical, and chemical engineering. There are, however, some kinds of construction which cannot be classified under any one of these subdivisions. For example, the design of modern movable bridges includes problems commonly considered as relating to these three fields of engineering—civil, mechanical, and electrical.

Movable bridges may be divided into six general types: (1) swing bridges, turning about a vertical axis; (2) bascule bridges, turning about a fixed or a movable horizontal axis, or rolling back on a circular segment; (3) lift bridges, rising vertically; (4) retractile bridges, moving horizontally; (5) transporter bridges, carrying a hanging moving platform; and (6) pontoon bridges, floating and swinging horizontally. Types 4, 5, and 6 are seldom required.

SELECTION OF PROPER TYPE

The selection of the type of bridge depends upon the physical conditions at the site, and the most economical design can be determined only by a thorough study of all these and of the character and amount of both bridge and channel traffic. The character and depth of the foundations will sometimes be a ruling factor, or the value of property on the shores of the channel or stream may determine the type to be chosen. However, there are broad general principles which should be considered. When a bridge is closed and ready for traffic, it should be as nearly as practicable a fixed span with positive reactions. The structural and mechanical parts should be separate and distinct. When the bridge is carrying traffic, the mechanism should not be under stress, and the machinery should be used only to move the span. The operating machinery should be of simple design, easily accessible for installation, maintenance, and repairs. If the bridge and mechanism are designed so that friction and lost work are at a minimum, the cost of construction and maintenance will also be the lowest possible. Some of the local conditions and characteristics, which indicate whether a swing, bascule, or vertical-lift span should be chosen, are stated in the following paragraphs.

ADVANTAGES OF SWING BRIDGES

Where the conditions at the site are favorable, a swing bridge is the simplest and best and it is the most economical in first cost and maintenance. In fact, the unit cost of a swing span is less than that of either a bascule or vertical-lift span. If the bridge is located where navigation is suspended during winter, the center pivots of center-bearing swing spans can readily be repaired or renewed. Among the advantages to be gained in this type of span is that all reactions are positive when the span is closed. The distribution of the weight of the bridge and its live load to the piers is better than in bascules. The center of gravity and the center of wind pres-

THE HEAVIEST SWING BRIDGE—HIGHWAY ABOVE, RAILWAY BELOW
Mississippi River Bridge at Fort Madison, Iowa, on the Santa Fe Railway

sure are low and at constant elevations so that the general stability is changed but little when the span is opened.

The superstructure has no mechanical joints, and the machinery is subjected to stress only when the bridge is being operated. Since the weight to be accelerated and the friction of the machinery are less than for most other types, less power is required. If the waterway is wide and only one channel is needed for navigation, the second arm forms a useful span and the length of the adjacent fixed spans is reduced.

In most locations the two arms of the span are of equal length and provide two navigable channels, thus dividing the water traffic passing in opposite directions. This is a considerable advantage from the point of view of safety in navigation.

THE PIVOT PIER AND OPERATING HOUSE
Mississippi River Bridge at Fort Madison, Iowa, on the Santa Fe Railway

BASCULE BRIDGES FOR NARROW WATERWAYS

Bascule bridges are adapted to locations where only one channel is needed and to cases of growing traffic which may require an additional bridge parallel to the one originally built. They are suitable in places where the waterway is too narrow for a swing span. A closed balanced bascule span has no dead-load reaction at the rising end, which must be latched down. Most bascules have large trunnions, some types also having systems of articulated links forming mechanical joints which are always under stress. They are difficult to lubricate, to maintain, and to repair. The power plant and machinery must be of ample capacity to overcome the friction of all trunnions and joints and to accelerate the mass of the span and its counterweights.

Generally the counterweights which must be used weigh from two to more than three times as much as the span, and the weight of the counterweights increases the loads which must be carried by the piers and foundations at the trunnion end of the span.

When open, the whole span is exposed to wind and the center of the wind pressure is much higher than when the span is closed. This requires additional power for operation, since the span must be held against the pressure of the wind when it is open. The general stability of the open span must be carefully investigated, and it is sometimes necessary to increase the width between the trusses and to make the masonry broader and larger in order to provide enough stability. Where the waterways are wide, the length of the fixed spans is greater than that which would be required in connection with swing spans.

One objection to the bascule type is that, with only one channel, there is more danger of collision between passing vessels than when there are two. Also, the unit cost of the bascule is greater than for swing spans or vertical-lift bridges.

VERTICAL-LIFT BRIDGES CONSIDERED

Vertical-lift bridges are adapted to about the same locations as bascules. Their spans have no positive reactions from dead load at either end when closed, and both ends must be latched down. When the span is raised, the center of wind pressure is higher than for bascules and general stability must be provided to meet this condition. This may make it necessary to increase the width of the bridge and the size of the piers and foundations.

The counterweights weigh the same as the span, thus being much lighter than those for bascule bridges of the same length. The two main piers carry equal loads, the distribution of loads to the piers and foundations being better than for bascules. The counterweights are usually attached to the ends of the span by wire ropes extending up and over large sheaves, which turn on trunnions on top of the towers. In some designs articulated links are used for this purpose. In either case, however, the mechanical parts are always under stress and must be carefully maintained. Moreover, repairs and renewals are difficult and expensive.

Where the waterway is wide, the length of the fixed spans is greater than would be required in connection with swing spans. Also the operating machinery must accelerate a greater mass than in a swing span, but less than in a bascule. However, the resistance from wind pressure is small, and the power required is intermediate between swing spans and trunnion bascules.

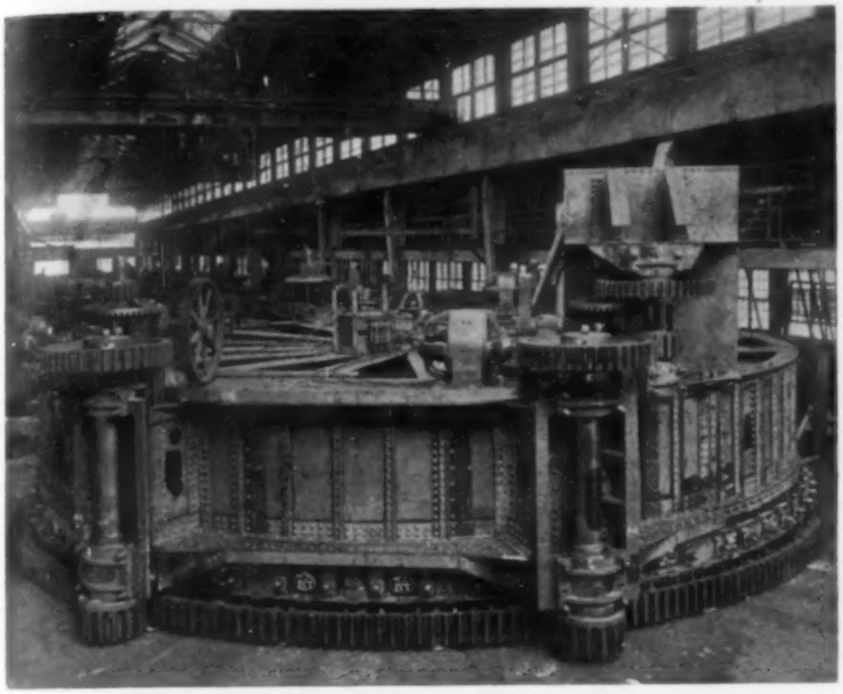
Since only one navigation channel is provided, there is the same danger of collisions with this type of bridge as with a bascule design. A vertical-lift bridge is less expensive than a bascule, the cost being intermediate between that for swing spans and bascules.

LOADS USED FOR DESIGN

Since the first cost of movable bridges, including their machinery and power plants, is so great, and the traffic delays, difficulties, and costs of reconstruction are so serious, the choice of loads for their design should be made with reference to future requirements as well as to present conditions.

Railway bridges should be designed to carry modern heavy live loads, and the calculated stresses should then be increased to provide for the dynamic effect of the passing loads. The system of live loads first proposed by the late Theodore Cooper, M. Am. Soc. C.E., com-

monly known as E loads, no longer represents modern locomotives. The present tendency is to use freight locomotives in which there are five driven axles, usually followed by one or two trailer axles under the fire box. The driven-axle loads are frequently as much as 70,000 lb. each, the loads on the trailer axles being nearly as great. Locomotive tenders are being increased in weight and length in order to provide for fuel and water for long runs. Many modern tenders have six axles with loads up to 60,000 lb., or even more. Train loads also have increased, but less rapidly.



Operating Mechanism Assembled in the Shop
Mississippi River Bridge at Fort Madison, Iowa, on the Santa Fe Railway

Highway bridges are now commonly designed for specified live loads on traffic lanes 9 or 10 ft. wide, and the width of the roadways is made in multiples of the lane width. Each lane is considered to be loaded by a line of trucks properly spaced for this purpose. The leading truck should be assumed to weigh not less than 20 tons, and those behind it to weigh at least 15 tons each. There are indications that these loads may be exceeded in the near future. The calculated stresses should be increased to provide for the dynamic effect of the passing loads.

Movable bridges should be designed for wind loads of 30 lb. per sq. ft. against the closed span and the live load upon it; 50 lb. against the closed bridge without loads; and at least 15 lb. per sq. ft. against the structure when it is open. In *Movable Bridges*, Vol. 2, page 262, I have proposed a specification for wind and lateral loads.

SWING-SPAN LOAD COMBINATIONS

The stresses in the superstructure should be calculated for various conditions of loading and properly combined to obtain the total stresses for which the members must be proportioned. The conditions of loading and their probable combinations will depend upon the type of design that is adopted. The usual combinations are given as follows:

Case 1. Dead load; bridge open or closed with no end reactions.

Case 2. Dead load; bridge closed with ends lifted to cause positive reactions equal to $1^1/_2$ times the maximum live-load negative reaction without impact.

Case 3. Live load; bridge closed but with no dead-load end reactions; one arm loaded and considered as a simple span.

Case 4. Unbroken live load; bridge closed and considered as a continuous girder.

Case 5. Unbroken live load; bridge closed and considered as a continuous girder, but with the live load placed so as not to cause negative reactions.

The proper combinations are Case 1 alone, Case 2 with Case 3, Case 1 with Case 5, and Case 2 with Case 4.

In ordinary swing spans, the calculations of the stresses for the continuous cases are first made from reactions determined from the common theory, assuming constant moments of inertia. In large and important structures, the stresses should then be corrected from the elastic relations of the trusses, as designed by the common theory, and the areas of the members readjusted accordingly.

The loads for maximum stresses in bascule spans are as follows:

Case 1. Dead load; bridge closed and considered as a cantilever.

Case 2. Dead load; bridge open at any angle.

Case 3. Live load; bridge closed and considered as a simple span.

The proper combinations are Case 2 alone, and Case 1 with Case 3. In Case 2 the dead-load stresses, which vary with the movements of the span, should be increased by 20 per cent in order to provide for dynamic effects.

The operating stresses caused by the acceleration and deceleration of the various parts of the structure, and due to the friction of the trunnions, joints, and mechanism, should be calculated. These forces may cause maximum stresses in some of the structural parts. Every unusual arrangement should be carefully investigated to determine sources of stress which are not apparent when casually considered.

Loads for vertical-lift spans follow:

Case 1. Dead load; bridge open or closed, as a simple span.

Case 2. Live load; bridge closed, as a simple span. In this instance, Case 1 combines with Case 2.

SELECTING POWER FOR OPERATION

The time available for operation is often fixed by public authority. If it is not so fixed, a study should be made of the traffic over the bridge and through the channel and a reasonable time for operation established.

For economy in cost of construction, operation, and maintenance, the time of operation should be as long as practicable. The power required is then at a minimum, for it should be remembered that the power for operation increases almost in inverse proportion to the cube of the time of operation. It should also be borne in mind that the cost of construction, operation, and maintenance of the machinery increases approximately with the power.

After the time of operation has been fixed, the power required to operate the bridge within that time can be calculated for the various operating conditions. These may be stated as follows:

1. In the normal time of opening:

a) Swing and vertical-lift bridges against frictional resistances and accelerating forces.

b) Bascule bridges against frictional resistances, accelerating forces, and a wind pressure of $2^1/_2$ lb. per sq. ft. of the span and its floor as seen in plan. This force shall be assumed to apply normally to the floor throughout the movement of the span whether the bridge is opening or closing.

2. In $1^1/_2$ times the normal time of opening:

a) Swing bridges against a wind blowing at a velocity of 50 miles per hour upon each truss and one floor system, as seen in elevation, assumed to apply to both arms and normally to the span throughout its movement when opening or closing, in addition to the forces specified in 1*a*. If V is the velocity of the wind in miles per hour, then the corresponding pressure per square foot of surface normal to the direction of the wind will be $P = 0.004V^2$.

b) Vertical-lift and bascule railway bridges, in locations where ice forms, with an ice load of $2^1/_2$ lb. per sq. ft. on 85 per cent of the area of a quadrilateral of which the width is the distance between the centers of the trusses and the length is that of the floor of the movable span, in addition to the forces specified in 1*a* or 1*b*. In highway bridges, the full area of the quadrilateral previously defined shall be considered as loaded with ice.

3. In twice the normal time of opening:

Bascule railway bridges, against frictional resistances, accelerating forces, and a wind pressure of 10 lb. per sq. ft. of area upon any vertical projection of the moving span and its floor; and in locations where ice forms, with an ice load of $2^1/_2$ lb. per sq. ft. on 85 per cent of the area of a quadrilateral of which the width is the distance between the centers of the trusses and the length is that of the floor of the movable span. In highway bridges the full area of the quadrilaterals previously defined shall be considered as loaded with ice.

4. Holding span:

On unequal-arm swing bridges and bascule bridges, the machinery shall be proportioned to hold the span in any position against a wind pressure of 15 lb. per sq. ft., applied on any vertical projection of the moving span. When proportioning the machinery for this condition, the unit stresses specified may be increased one-fourth.

Although the most independent and reliable source of power is a steam engine, its construction and operating costs are too great for most locations. Consequently, if current is available, some type of electric motor is at the present time the most economical and convenient source. But if electric current is not available, internal combustion engines are the second choice. These, however, have the disadvantage of giving small starting torques, and this must be overcome by clutches and gearing. Also, they are not reversible, which adds to the complication of the mechanism.

TWO-LEAF TRUNNION BASCULE LIFT BRIDGE
Genesee River Bridge at Charlotte, N.Y.

After the time of operation, the power required to move the bridge within that time, the type of motor, and the gear ratio have been determined, the stresses in the gear trains must be calculated. If alternating-current electric motors are to be used, the gear trains should be designed for their maximum torques. If the motors are of the direct-current crane type, it may be necessary to limit their maximum torques by the use of automatic circuit breakers. The gear trains would then be proportioned for the predetermined maximum torques. If internal combustion engines are used, the maximum torque will depend upon the type and design which are chosen.

Since fly wheels are seldom heavy enough to prevent some shock from the explosions, near the engines the gear trains should be designed for torques greater than the normal torques corresponding to the normal engine rating. The maximum torque of a four-cylinder four-cycle engine, running from 1,000 to 1,400 r.p.m., is about 125 per cent of the normal torque. It is about 225 per cent of normal for a one-cylinder four-cycle engine running from 200 to 350 r.p.m., and usually varies between these limits for other ordinary four-cycle engines.

The friction of the mechanism varies with the materials used, their surface condition, velocity of movement, lubrication, and other factors. Most of the data on friction, in treatises and handbooks on machine design, are given for machine elements moving at such velocities that full oil films are established. In movable bridge machinery, motor armatures and the high speed shafts of speed reducers are about the only shafts which rotate at sufficient velocities to allow full oil films to be de-

veloped. All other bearings should be considered to have broken oil films and the coefficients of friction should be chosen for this condition. A few average values, indicating some of the complexities of the design of

Vertical-Lift Bridge
Over Piscataqua River at Portsmouth, N.H.

movable bridge machinery, are given in the following table.

Coefficients of Friction

Wedges on each surface	0.15
Discs of center-bearing swing spans	0.15
Large trunnions	0.15
Horizontal line shafts	0.05
Vertical shafts	0.06 to 0.10
Segments of rolling-lift spans	0.009
Sliding guides of vertical-lift spans	0.10
Rollers bearing on two lines (in which r is the radius of the roller in inches)	$\frac{0.008}{\sqrt{r}}$
Efficiency of spur gearing	95 to 97 per cent
Efficiency of bevel gearing	92 to 95 per cent
Stiffness of wire ropes (in which d is the diameter of the rope and D that of the sheave)	$0.45\frac{d}{D}$

DESIGN OF MACHINERY

The arrangement of the machinery should be as simple as possible; flimsy and complex devices should be avoided. The various parts of the mechanism should be easily accessible, as too little attention has been given to convenience in maintenance, repairs, and renewals. If the arrangement is simple and the parts are few in number, the work lost by friction is reduced to a minimum.

Gear trains should be designed so that they can be made, adjusted, and installed as compact units which can be quickly assembled on the structural parts of the bridge. There are now speed reducing units which can be installed adjacent to the motor, thus greatly simplifying the arrangement of the reduction gearing. Since bearings that are difficult to oil will be neglected, the arrangement should provide easy access for lubrication of them.

No shaft should pass through a structural member unless the opening is sufficiently large and so located that the shaft, with its gears attached, can be removed for purposes of repair or renewal. Bevel gears should be avoided. However, if they must be used, the shafts of each pair should be boxed in a union bearing in order to insure alignment and perfect meshing of the gears. All shafts should be correctly aligned and all gears set so that they mesh on the true pitch circles.

Another important consideration is the arrangement of shaft bearings. If practicable, the gears should be between these bearings and near one of them. Shafts which are deflected by the elastic movements of the structural frame of the bridge should not be connected by flanged couplings. Instead, flexible jaw couplings, or their equivalent, should be used. When a movement must be completed after a definite cycle, the shafts should be investigated for elastic torsional stiffness as well as for strength.

In cases where one motor is used to drive more than one main pinion, as in heavy swing bridges and some bascules, an effective equalizer should be inserted in some shaft near the motor, so that both pinions will carry equal loads. Practically all machinery is assembled on structural parts, which cannot be made and installed with the high degree of accuracy that is necessary in machinery. Shims, or other means of adjustment, should be provided between the structural and mechanical parts, and all line shafts, gears, and other parts must be accurately adjusted to lines and positions.

Trunnions carrying large loads are often used on bascule and vertical-lift bridges, and the trunnions, bearings, and their supports should be designed to avoid elastic deflections which would throw the trunnions out of alignment and cause unequal pressures on the bearings. In fact, there is no part of a movable bridge which requires more perfect adjustment than heavy, slow-moving trunnions.

BRAKES ARE IMPORTANT

Effective brakes should be provided on the main driving mechanism of all types of movable bridges that are operated by power. Solenoid brakes on the armatures or countershafts of motors are found to be convenient and effective on motor-operated bridges. In addition to these, emergency brakes of sturdy construction should be provided for unusually large and heavy swing and vertical-lift bridges and for all bascules. Since bascule and vertical-lift bridges must be brought to rest in their fully open and closed positions, air buffers should be provided to assist in stopping them without shock.

One of the most common causes of trouble in movable-bridge machinery is the neglect to make adequate provision for the effects of vibration, particularly in a plane at right angles to the plane of the principal stresses. In fact, vibrations of machinery supports may cause great damage and much increased friction, so particular care should be taken to stiffen the structural supports.

Few shafts in movable-bridge machinery require investigation for the critical speeds at which their vibrations are at a maximum. However, some long shafts rotating at high velocities may need study. The most effective remedy for excessive vibration is to place the bearings nearer each other, and the next best is to make the shafts larger.

MATERIALS OF CONSTRUCTION

The superstructure of movable bridges will usually be constructed from structural open-hearth steel made in accordance with the specifications for bridges of the American Society for Testing Materials, which also issues specifications for castings, forgings, cold-finished steel, bronze, white bearing metals, and a variety of other materials.

Selection of the materials most suitable for the lining of the bearings of shafts and trunnions, and for the center discs of center-bearing swing spans, requires good judgment and a thorough knowledge of the characteristics of a variety of bearing metals. Much depends upon the use of suitable metals, their proper combinations, installation, and effective lubrication; and failures have been caused by the use of soft metals under heavy pressures, hard, brittle metals in small bearings, and so-called manganese bronze as a bearing metal. However reliable this bronze may be in tension, it is not suitable for bearing linings as it abrades under low pressures and seizes at relatively low velocities. A soft steel shaft running in an unlined bearing of forged or cast soft steel will heat and seize. It must be remembered that exact knowledge is the price of success in the design of bearings and mechanical joints.

UNIT STRESSES USED FOR DESIGN

Suitable unit stresses for the design of the superstructure of movable bridges are given in many specifications, those published by the American Society of Civil Engineers and the American Railway Engineering Association being among the best. The ordinary tensional basic unit stress for steel-bridge superstructures is from 16,000 to 18,000 lb. per sq. in. Unit stresses in structural-steel machinery supports subject to vibration should not exceed 10,000 lb. per sq. in., and such members should be well stiffened transversely.

In bearings, levers, bell cranks, pins, and bolts, maximum unit stresses should not exceed 10,000 lb. per sq. in. for either rolled or cast steel. If cast iron is used, the unit stresses should not exceed 3,000 lb. in tension, 4,000 in bending, or 8,000 in compression. The bending unit stress on annealed carbon steel trunnions should not exceed 15,000 lb. per sq. in. When designing ordinary steel shafts, the torsional and bending moments should be reduced to the equivalent combined torsional moments and the torsional unit shear should be limited to 8,000 lb. per sq. in.

The determination of the permissible unit stresses and bearing pressures on such parts as journals, gears, worms and wheels, discs, collars, wedges, axles, screws and nuts, and springs, is too complicated for brief statement

EFFECTIVE LUBRICATION IMPORTANT

Provision should be made for the effective lubrication of all parts which move against each other. Oil holes and oil grooves are essential, while closed oil cups should be used on all important bearings. Plugs may be used to close holes in unimportant bearings, but no oil hole should be left open in cases where dirt and water can pass through it into a bearing.

Oil grooves are most effective if their length is at right angles to the direction of movement. Also, they should be of ample size, with the external corners well rounded

SINGLE-LEAF ARTICULATED-LINK BASCULE BRIDGE
Wabash R.R. Bridge over River Rouge, Detroit

so as to draw in the oil between the moving and fixed surfaces of the bearing. Auxiliary grooves are often used to feed oil to the main ones. Grooves with sharp corners are almost useless, and the crooked and complicated grooves formerly used are in nearly all cases less efficient than those which are straight. One of the best arrangements for ordinary shaft bearings is to round the adjacent corners of the box and the cap, the rounding to be stopped near the ends of the bearings and caps. An oil hole is then drilled in the cap communicating with a semicircular groove cut in the inside of the cap which connects with the grooves formed by the rounded corners of the box and cap. Large bearings should be made so that their oil grooves can be cleaned out if they become clogged.

If a solid grease is forced into the grooves by pressure, a few revolutions of a shaft will carry away all of the grease which touches the shaft and there will then be no more lubrication until pressure is again applied. Fluid mineral oils of suitable body and viscosity afford better lubrication than solid greases because oils feed by gravity and by capillary action, and are drawn into the bearings by the rotation of the shafts.

There are records of movable bridges which were built before the Christian era, and of many constructed in early times as parts of fortifications. Others were made movable in order to provide for navigation in streams crossed by roads. In the many small draw bridges built during the Renaissance, engineers used ingenious methods of counterbalancing that are now characteristic of some modern types. The great increase of transportation which followed the invention of the steam locomotive, and later, that of the electric motor and internal combustion engine, created a demand which has been met by the development of the many modern types of movable bridges. Their design and construction has become a specialty, and it is likely that improvements in their superstructure, machinery, and power plants will continue for many years.

Basic Principles of Concrete Making

Quality Determined by Properties of the Hardened Cement Paste

By F. R. McMillan

Member American Society of Civil Engineers

Director of Research, Portland Cement Association, Chicago

In summarizing the results of tests and studies made by his organization to determine the strength, durability, and permeability of cement concrete, Mr. McMillan here establishes the basic principle that the characteristics of the hardened cement paste determine the quality of the concrete mixtures which can be designed from it. Of particular interest to engineers, he finds that concrete of higher compressive strength is also more watertight, and that the very desirable qualities of strength, watertightness, and durability go hand in hand with a low mixing-water content, or water–cement ratio. This enlightening paper has been prepared from a lecture delivered by Mr. McMillan at the 1930 Summer Session of the Society for the Promotion of Engineering Education, at Yale University.

UNTIL quite recently, the material available on concrete did not lend itself readily to a simple analysis. The various properties of concrete and the factors influencing these properties were treated almost as if they were wholly unrelated. One of the reasons for this was the practice of thinking of concrete as a four-component mixture, that is, a mixture of cement, fine and coarse aggregate, and water. With each element of the mixture subject to a number of possible variations, it was difficult to discover any general laws of behavior.

If concrete is thought of as a two-component mixture, cement paste and aggregate, the number of variables is greatly reduced, and the formulation of a complete technology is materially simplified. When concrete is considered as a mass of aggregate held together by the hardened cement-water paste, it is only necessary to know the properties of this paste and the laws governing its combination with the aggregate in order to understand the character of the concrete itself.

DETERMINING PROPERTIES OF CONCRETE

For purposes of clarity it seems desirable to state my principal conclusion first, thus making it possible to point out the limitations under which it is intended to apply. What follows will show that, when the concrete is so made and placed that the aggregate is completely surrounded by the cement-water paste, forming a uniform and homogeneous mass, the properties of the concrete are principally determined by the properties of the hardened paste.

The requirements that the concrete be uniform and homogeneous throughout and that the aggregate be completely surrounded by the paste, are essential. Thus it is necessary to consider not only materials, proportions, and consistency, but also adequate mixing and, most important of all, proper handling and placing. These last mentioned requirements must be kept in mind throughout this discussion for, no matter how skillfully the concrete mixtures are designed, complete success will not be assured unless the concrete is properly handled and placed.

It is true that certain characteristics of the aggregate affect the properties of the concrete, in some cases to a marked degree. This does not, however, reduce the importance of the paste for, regardless of the kind or combination of aggregate, any change in the properties of the paste will be at once reflected in the character of the concrete. Variations in the quality of the concrete resulting from variations in materials should not be allowed to obscure this fact. Even though the materials are selected to take advantage of every possible improvement in quality, the final product must still depend on the quality of the hardened paste.

CHARACTERISTICS OF THE CEMENT-WATER PASTE

The chemical reactions responsible for the setting and hardening which transform the plastic cement-water paste into a hard, binding medium are termed hydrolysis and hydration. For the completion of these reactions three things are required—included under the general term, curing conditions—time, favorable temperature, and the continued presence of water. While there is at present no measure of completeness of hydration, tests and experience have shown that any curtailment of these curing conditions interferes with the full development of the potential quality of the hardened paste.

Development of quality by additional curing is well illustrated by the curves in Fig. 1. Here two of the elements of curing, temperature, and moisture conditions, are not allowed to vary, so that all the improvement in quality—strength, in this illustration—must come from additional time.

This chart is based on tests of concrete made from 32 cements, which were carried out for Committee C-1 of the American Society for Testing Materials. The curve, *E*, has been added for a high early strength cement. In this set of tests time becomes, in a sense, a measure of completeness of hydration for the constant temperature and humidity conditions. The shaded area on the curve represents a belt 10 per cent above and below the average strength for the 32 cements. Figures in the circles give the number of cements falling within and without this area.

FACTORS AFFECTING STRENGTH

This diagram shows that hydration is substantially complete at from 6 to 12 months, both for the 32 standard portland cements and for the high early strength product. For shorter periods, the strengths are correspondingly less. Thus it will be seen that two of the factors which control strength are completeness of hydration and characteristics of the cement.

A third factor which must be recognized as fixing the quality of the hardened paste is the proportion of its two ingredients, cement and water. In this respect, cement paste does not differ from other chemical or physical

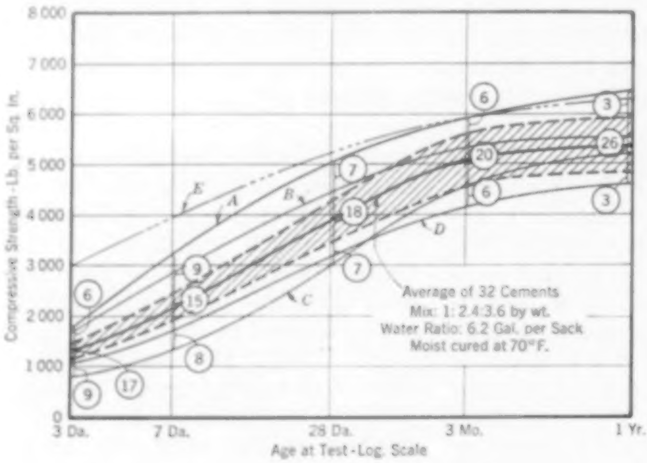


FIG. 1. AGE-STRENGTH RELATION FOR CONCRETE

mixtures. Any water beyond the amount which can chemically combine with the cement merely dilutes the mixture and reduces its potential strength, or water-tightness. In Fig. 2 is brought out very clearly the effect of different proportions of cement and water on the compressive strength of the hardened paste. These data, which are for neat cement pastes, also show the effect of age or continued curing at 70 deg. fahr. and 100 per cent humidity.

From the foregoing it can be seen that there are three factors upon which the strength of the hardened water-cement paste depends. These can be conveniently summarized as follows:

1. Relative proportions of cement and water, or the water–cement ratio
2. Completeness of the chemical combination between the cement and water, that is, curing
3. Characteristics of the cement

In the succeeding paragraphs, through a study of the properties of concrete, it will be shown that these three factors also determine the other properties of the hardened paste.

The effect of the water–cement ratio on the compressive strength of concrete is so well recognized as to require no particular consideration here except to point out some of the factors which affect it. The relation of water–cement ratio to flexural strength has been found to be somewhat the same as its relation to compressive strength. This is shown in Fig. 3, together with a similar set of data on tensile strength, taken from a paper, "Flexure and Tension Tests of Plain Concrete," by Gonnerman and Shuman, included in the 1928 Report of the Director of Research of the Portland Cement Association, page 137.

Aside from those due to the characteristics of the cement, the principal variations in the position of the water-ratio strength curve are those introduced by such properties of the aggregate particles as absorption, surface texture, size, shape, and strength. Not all these factors have been fully investigated, but enough data are available to show something of the possible range which may be expected.

EFFECT OF CHARACTERISTICS OF COARSE AGGREGATE

Regarding strength in compression, Professor Giesecke has shown that variations in coarse aggregate, ranging from 4,000 to more than 30,000 lb. per sq. in., produce practically no change in the strength of a concrete of given cement content. His tests cover mixes ranging from 6 to 14 sacks of cement per cubic yard, as described in *Engineering News-Record* for June 29, 1922.

The size of the aggregate particles has been shown to affect the position of the water–cement ratio strength curve for concrete, particularly in the large sizes. However, for sizes up to 3 in., if the size of the specimen is properly related to the size of the aggregate, the effect is not of great importance in comparison with the factors controlling the strength of the hardened paste. If the size of the aggregate particles is greater than from 20 to 25 per cent of the diameter of the test specimen, a direct falling-off in strength is noted.

Differences in absorption also affect the position of the water-ratio strength curve for different aggregates unless such differences are taken into account. Obviously, any water taken from the paste during the operation of mixing and placing cannot be considered as belonging to the paste.

The other characteristics of aggregates which have an effect on the position of the water–cement ratio strength curve—surface texture and shape—have not been investigated thoroughly. Something of the effect of these factors, however, can be learned from a report by W. F. Kellerman, in *Public Roads* for June 1929, of tests in

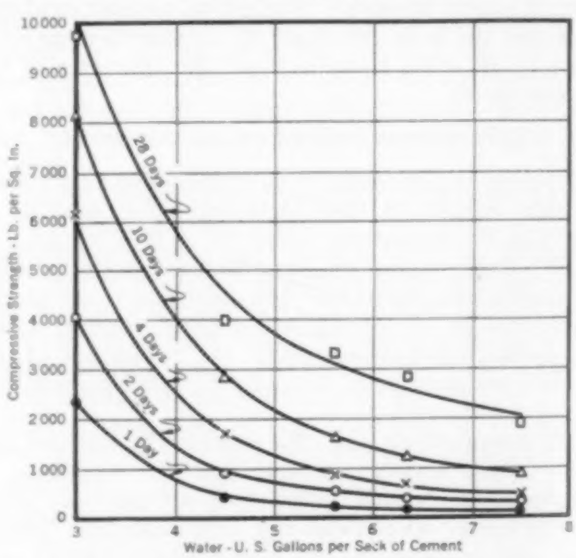


FIG. 2. RELATION BETWEEN WATER–CEMENT RATIO AND STRENGTH IN COMPRESSION

2 by 4-In. Cylinders, Neat Cement, Moist Cured

which the other factors were fairly well controlled. This report presents the results of experiments on 14 typical coarse aggregates, including 7 gravels and 7 crushed stones, selected to give as wide a range in physical characteristics as possible. These were studied in four different gradings and four different mixes.

In compression, all of the materials gave typical water–cement ratio strength curves, which represented a spread of about 700 lb. per sq. in. Of the 14 curves, however, 10 fell within a belt less than 200 lb. per sq. in. in width. This is an extremely small variation for tests of this kind. The curves for the modulus of rupture were not grouped as were those for compression. They were quite uniformly spaced over a range of about 150 lb. per sq. in. Similarly, the Gonnerman and Shuman tests showed a greater influence of the aggregate characteristics on flexural strength.

Abrams has shown that the bond between steel and concrete and the resistance of concrete to wear are both affected by the water–cement ratio in the same general way as is the compressive strength.

Effect of Water–Cement Ratio on Watertightness

Results of tests by the Department of Industrial and Scientific Research, London, are shown in Fig. 4, in which the leakage through a specimen under a pressure of 100 lb. per sq. in. is seen to increase consistently with an increase in the quantity of mixing water above the values of about 6.7 gal. per sack. The increase in leakage for quantities of water less than this is due to the difficulty of properly molding mixtures of drier consistency. These tests were all made on a 1:2:4 mix so that,

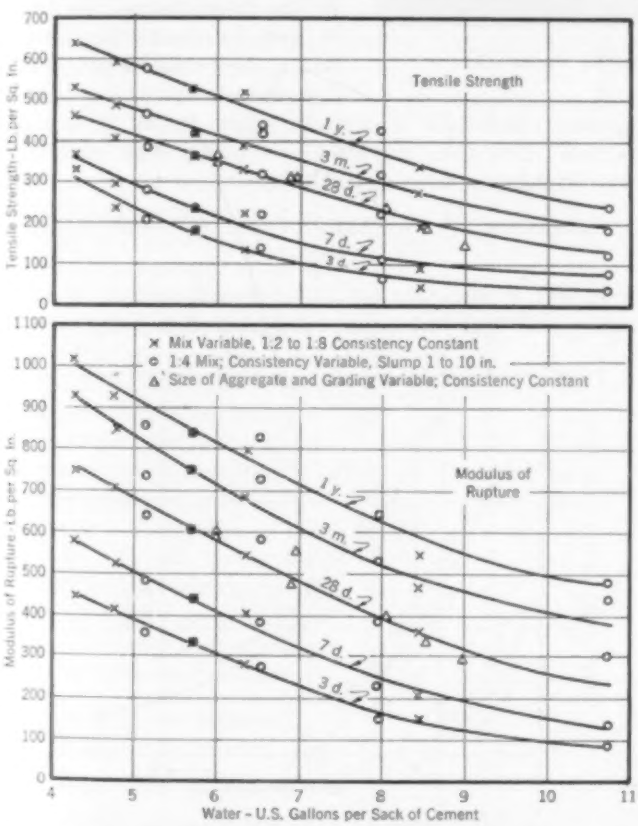


Fig. 3. Relation Between Water–Cement Ratio and Strength of Concrete in Tension and Cross Bending

with each change in water quantity, there was a change in consistency.

In Fig. 5 are indicated some tests from the Research Laboratory of the Portland Cement Association on 6 by 1-in. moist-cured mortar discs, in which the principal variable under consideration is the age of the specimen at the time of test. Separate curves, however, are shown for mixes of three different water–cement ratios so that the important effect of this factor on watertightness

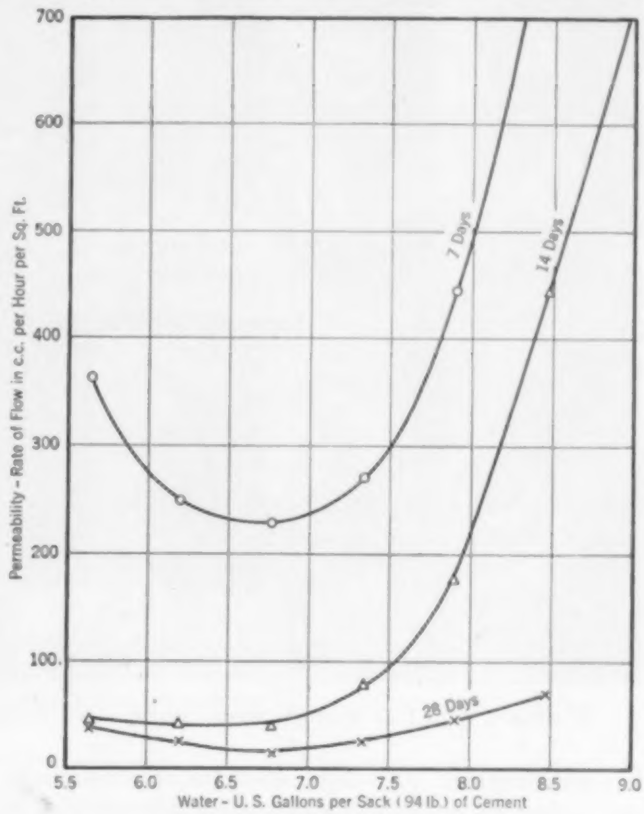


Fig. 4. Relation Between Water–Cement Ratio and Permeability of 1:2:4 Concrete

is also brought out. Each point on the curves is the average result of the leakage test on three specimens. The discs were tested at a pressure of 20 lb. per sq. in. each for a 48-hour period.

Under the conditions of this test, a mix having 5.6 gal. of water per sack of cement is absolutely watertight when tested at the age of eight days; while one for 7.3 gal. shows an average leakage of 400 cc. per hr. per sq. ft.; and a mix having 9 gal. of water per sack of cement has a leakage of 1,000 cc. per hr. per sq. ft. under the same conditions.

Water–Cement Ratio Affects Durability

In the *Proceedings* of the American Society for Testing Materials, Vol. 2, Part 2, 1928, Prof. C. H. Scholer showed that the water–cement ratio has an effect on the resistance of concrete to the destructive effects of repeated freezing, comparable with the effect on compressive strength. Tests at the Research Laboratory of the Portland Cement Association have confirmed these conclusions.

Typical of these data are the 6 by 12-in. specimens pictured here after 60 cycles of freezing and thawing. The mix in both groups of specimens was 1:2:4 in dry, compact volumes with water ratios of 9 and $7^1/_2$ gal. per sack. Elgin sand and gravel were used as fine and coarse aggregates, and specimens were cured 28 days in the moist room before being exposed to alternate freez-

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CONCRETE WITH LOW WATER-CEMENT RATIO MORE RESISTANT TO FROST ACTION

ing and thawing. As will be seen, the specimens with the higher water ratio showed considerable spalling of the surface, while those with the $7^1/_2$-gal. water ratio were still practically unaffected by the action of frost.

At the conclusion of the 60 cycles, the specimens were tested in compression. The results of these tests, together with the strengths at 28 days, are shown in Table I.

TABLE I. RESULTS OF FREEZING AND THAWING TESTS ON CONCRETE

Water-Cement Ratio	Compressive Strength in Lb. per Sq. In.	
	At 28 Days Moist Cured	After 60 Cycles of Freezing and Thawing
$7^1/_2$ gal.	2,420	4,070
9 gal.	1,280	1,940

The increase in strength of both mixes during 60 cycles of freezing and thawing is about the same as would be expected for the same period, 11 months, in ordinary moist curing. The long time required to produce this number of cycles—due to an overloaded refrigerator—together with the effect of the warm water used in thawing the specimens, accounts for the large increase in strength during the 60 cycles of freezing. Had it been possible to obtain this number of cycles in a shorter period, a greater effect of the frost action would, no doubt, have been noted.

STRENGTH AND WATERTIGHTNESS INCREASE WITH AGE

In the development of compressive strength in concrete, the effect of continued curing is so well recognized that it requires no discussion here. In the data of Fig. 1, a steady increase was shown in compressive strength of concrete from three days to three months, for the 32 standard portland cements. For periods subsequent to three months, most of the cements showed only a slight increase in strength. Even in the case of the special high early strength cement, a considerable curing period was necessary to develop its full potential strength. In Fig. 3, the effect of continued curing in adding to both flexural and tensile strength was clearly brought out.

Tests made by the Department of Industrial and Scientific Research, previously referred to, bring out clearly the effect of continued curing on the development of watertightness. In these tests, the leakage at 28 days was less than 0.5 that at 14 days and only about 0.1 that at 7 days.

The effect of continued curing is very prominently shown in the data of Fig. 5, where results of tests at three different ages are shown for each of the three mixes. In these it can be seen that mixes which show considerable leakage when tested at one period become practically watertight when tested at a later period. The time required to develop this additional watertightness varies with the mix.

RELATION OF WATERTIGHTNESS TO COMPRESSIVE STRENGTH

In Fig. 6, the data for two different periods of moist curing and four water ratios are plotted to bring out the

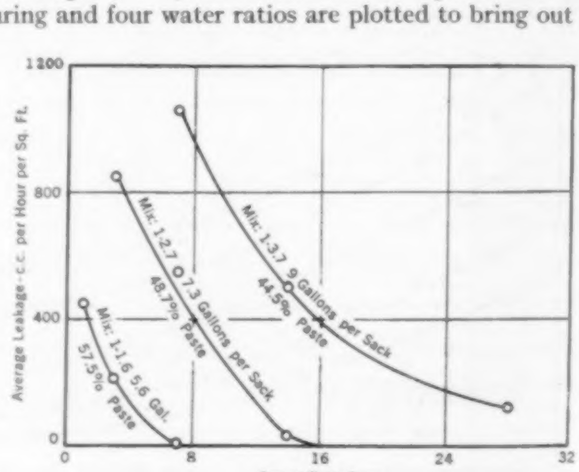

FIG. 5. RELATION BETWEEN TIME OF CURING AND PERMEABILITY OF CEMENT MORTAR

relation between watertightness and compressive strength. In these tests, molded discs of laboratory cement, 6 by 2-in., were tested at 80 lb. per sq. in. Each plotted point is the average value of 12 specimens, tested at 28 days. The curves show increasing water-

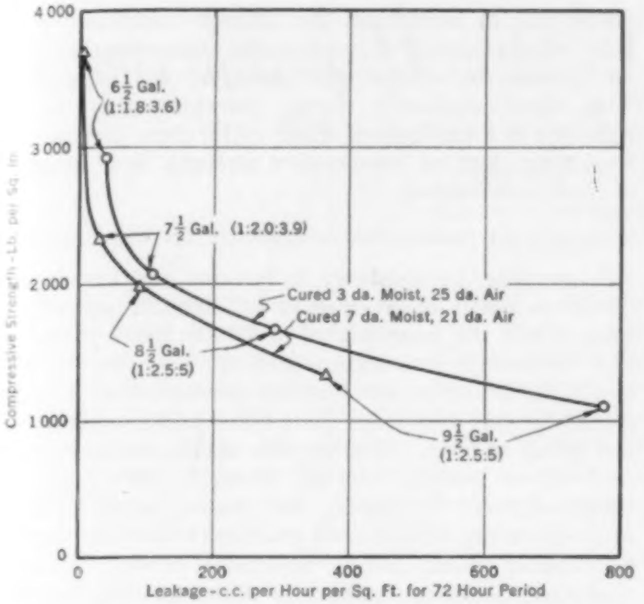

FIG. 6. RELATION BETWEEN PERMEABILITY AND COMPRESSIVE STRENGTH

tightness and compressive strength as the water-cement ratio is decreased and the moist curing period lengthened.

It is consistent with the facts already brought out that two separate curves are required, one for each moist curing period; also that increases in strength beyond a certain value are not accompanied by a corresponding increase in watertightness. Since, for each condition of test, there is some water-cement ratio or degree of curing that will give practically watertight concrete, there is no way to record further improvements in watertightness without changing the conditions of the test. Naturally, therefore, increases in compressive strength could not be accompanied by corresponding increases in watertightness. The curves in Fig. 6 are of particular interest in the discussion of the following paragraphs, where differences in cement characteristics are considered.

CHARACTER OF CEMENT AFFECTS STRENGTH

In presenting Fig. 1, the differences in rate of hardening among different cements were pointed out. Referring again to this chart, it will be seen that the greatest difference in strength exists at early periods and that, at the age of from three months to one year, the strengths tend to approach each other. This is shown by the numerals in the circles, indicating the number of cements falling within and without a belt 10 per cent above or below the average. At the end of a 7-day period, 15 cements are seen to fall within this range; at three months this number has increased to 20; and at one year, to 26. The special high early strength cement shown by curve *E* is also seen to come within the range of the normal portland cements after three months.

For individual cements, curves *A*, *B*, *C*, and *D* show the four types which embrace the entire 32. Type A starts high and remains high with relation to the average for the entire period; while type B starts high and falls off to about the average; type D starts low and remains low; and type C starts low but gains in strength relatively until it is at about the average in one year.

This group of 32 cements can be taken as representative of the American product, since every section of the country was represented in the selection of samples to be tested. These samples were purchased from dealer's stock, so that different storage periods may be responsible for some of the differences exhibited. No attempt was made to determine the date of manufacture.

EFFECT OF CHARACTER OF CEMENT ON WATERTIGHTNESS

A comparison of the watertightness of concrete made from different cements, for a considerable range in properties, is given in Fig. 7, in which are shown the

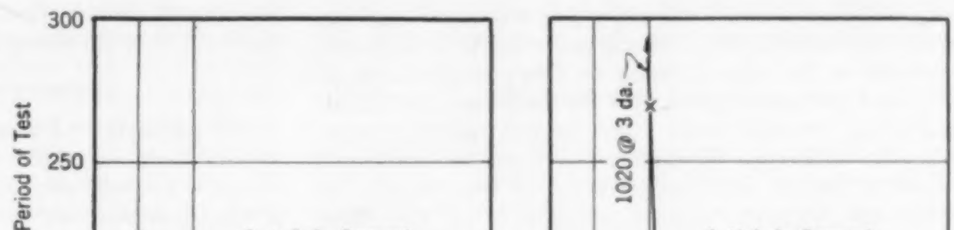

FIG. 7. PERMEABILITY OF CONCRETE FROM HIGH EARLY STRENGTH CEMENTS

results of tests for an average portland cement and for three special high early strength cements. A pressure of 80 lb. per sq. in. was used on 6 by 2-in. concrete discs, which had been moist cured until tested. These results are plotted in the same manner as those in Fig. 5 except that, in Fig. 7, each curve represents a separate cement, while in Fig. 5 each curve indicates a different water

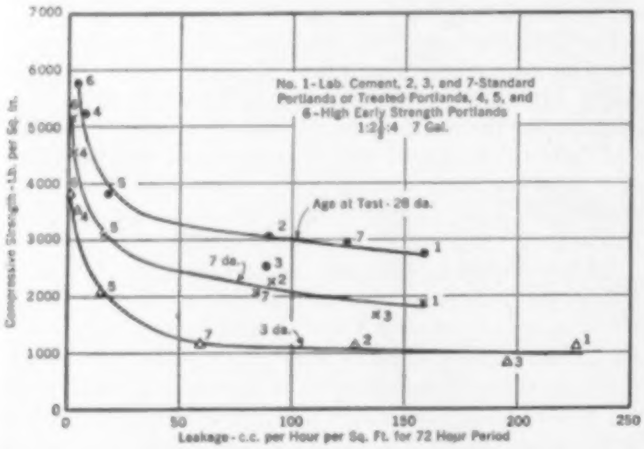

FIG. 8. RELATION BETWEEN PERMEABILITY AND COMPRESSIVE STRENGTH

Standard and High Early Strength Cements

ratio. As in the case of the specimens shown in Fig. 5, these were moist cured until the time of the test. A study of Figs. 5 and 7 will show that water ratio and age affect the watertightness of specimens made from special cements in the same manner as they do specimens of standard portland cement. At the early ages, the rapid-hardening cements show much greater watertightness, but the difference is rapidly overcome by additional curing or longer period under test. In this respect, the difference between various cements is of the same character as that shown in the comparison of compressive strengths.

The fact that differences between cements affect watertightness in the same way that they do compressive strength is more clearly illustrated in Fig. 8. This chart, which is similar in all respects to Fig. 6, shows the relation between compressive strength and leakage for the same four cements appearing in Fig. 7, together with three others, one of which is a standard portland, and two are treated portland cements.

In this diagram, Fig. 8, the compressive strengths were taken on 3 by 6-in. cylinders of $1:2^1/_2:4$ concrete, mixed with 7 gal. of water per sack of cement used, moist cured three days, and then cured in air until the tests were made. For the permeability test, 6 by 2-in. concrete discs were subjected to a pressure of 80 lb. per sq. in. for 72 hours. Each point on the curve is the average result from four specimens.

It will be seen that the curves in this chart are exactly similar to those in Fig. 6, a separate curve being required to show the relation between compressive strength and watertightness for each condition of curing. The points on the curves representing different cements have positions similar to those on Fig. 6, representing different water ratios. This shows that, as the compressive strength increases, due either to increased curing or a faster rate of hardening, the leakage is reduced to a point where further improvements, commensurate with an increase in compressive strength, are impossible. This direct similarity shows, therefore, that watertightness is a function of water ratio, time, and rate of hardening, just as compressive strength is a function of these same factors.

EFFECT OF CHARACTER OF CEMENT ON DURABILITY

As regards the resistance to freezing and thawing of concretes made from cements of different properties, there is not the same wealth of data available as in the case of strength and watertightness. Such data as are available, however, are entirely consistent with what would be expected from the permeability studies. In one group of tests, 1:2:3 concrete specimens made from cements of widely varying strength characteristics, when subjected to freezing and thawing after 28 days of moist curing, have shown practically the same results for similar water ratios, regardless of the strength characteristics or watertightness shown at early periods. Such performance is to be expected, for the permeability data have shown that mixes of this character, after 28 days of moist curing, are practically watertight.

An extensive study of structures in service has shown that the two principal disintegrating agencies are repeated freezing and thawing and the solvent action of percolating water. Thus, the evidence offered by the freezing and thawing and the permeability tests indicates that, in ordinary exposure, the characteristics of the cement should affect durability in exactly the same way that they do strength and watertightness.

SUMMARY OF CONCLUSIONS

The properties of cement paste, as brought out by various tests on concrete and mortar, have been discussed in considerable detail with a view to establishing in a fundamental way the basic principle that the properties of the hardened cement paste must, in the main, determine the quality of the concrete. With this fact established, the whole subject of concrete mixtures becomes clarified and the rules for the design of concrete mixtures greatly simplified.

Since the character of the cement and degree of curing are factors independent of the quality or combination of the aggregate, the principal factors in the design of mixtures are embraced under the heading, proportion of water to cement. The use of the water–cement ratio as a basis for proportioning concrete has been widely heralded and quite generally accepted. Many engineers, however, have been slow to accept this method of design. In some cases, their reluctance has been due to the fact that the position of the water–cement ratio curve for different cements and aggregates is not always the same. Another factor which has prevented a more general acceptance of this method has been the lack of convincing proof that properties of concrete, other than compressive strength are governed by the water–cement ratio. The preceding discussion should largely dispel such misgivings and establish confidence in the general applicability of this method of design. Future researches should endeavor to define more closely the limits of its application and to find a sound explanation for such variations from this simple principle as occur.

Constructing World's Longest Subway Station

Novel Methods Used on a Section of New York's Eighth Avenue Line

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Many unusual methods were used in the construction of the new Eighth Avenue Subway, especially in the segment extending under Eighth Avenue from 38th to 48th streets. This section is particularly interesting because it contains the 42d Street station, the longest subway station in the world; it traverses New York's hotel and theatrical district, notorious for its traffic congestion; and it underlies a network of arteries supplying this great center of the city with light, power, communication, water, gas, and sewage disposal, as well as mail tubes, Stock Exchange wires, and fire, police, Western Union, and Postal Telegraph cables.

From the south building line of 40th Street to the north building line of 44th Street, a distance of 1,215 ft.—this is the extent of the 42d Street station at Eighth Avenue, New York, the longest subway station in the world. It is 100 ft. wide, and completely fills the area between the building lines of Eighth Avenue. This station has three levels; a mezzanine floor, a main track floor, and a lower track and platform, the lowest depth being 50 ft. $4^1/_2$ in. below the street. The mezzanine floor has 15 station entrances, including one through the Hotel Lincoln and one in the Franklin Savings Bank, and later it will be connected by a ramp to the Queensboro Subway under Times Square.

On the main track floor are two island platforms, which are staggered, the west platform extending from 40th to 42d streets and the east platform from 42d to 44th streets. Below the main track floor is a lower track and platform which will be the terminus of the 53d Street Subway to Queens. This lower track will be connected to the mezzanine floor by two sets of escalators as well as by stairways. The two island platforms on the main track floor and the lower track platform are each 660 ft. long. This makes it possible for 5 trains of 10 cars each to load and unload passengers simultaneously. Capable when loaded of carrying 220 passengers apiece, these cars will be 60 ft. 6 in. long. The trains will be able to run on a schedule of 33 every hour, so that 12,100 people can be transported through the station every two minutes, or 363,000 per hour.

Before this station could be constructed, however, much work had to be done. The major parts of the work, on the section extending from 38th to 48th streets, which were started immediately after the contract was signed, were the installation of a temporary gas by-pass, underpinning, installation of electric compressors and machine shops, and excavation. A study of the contract, showing the progress of the work, is shown in the chart, Fig. 1.

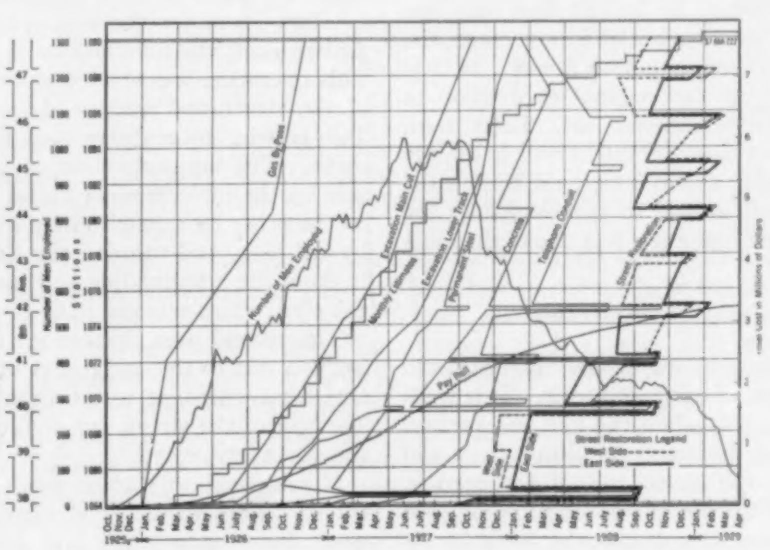


Fig. 1. Progress Chart and Study of the Subway Contract

BY-PASS PIPES INSTALLED

Both 12-in. and 24-in. temporary gas by-pass pipes were used, and these were laid at the curb line where they could be freely inspected and yet protected. They were carried over Eighth Avenue at 42d, 43d, 46th, and 47th streets, and under the cross streets, but far enough back to eliminate danger from the wooden decking catching on fire. The pipes that went across Eighth Avenue were suspended by vertical hangers from two $1^1/_2$-in. steel cables supported at the ends by steel towers 60 ft. high, thus providing a 35-ft. clearance above the street.

UNDERPINNING METHODS

Throughout the job the same general type of underpinning was used, although it varied in heaviness to suit different conditions. A typical example would be the underpinning of the old four-story brick buildings on the west side of Eighth Avenue from 44th to 45th streets, as shown in Fig. 2.

First, a trench was dug exposing the lower edge of the footings for the entire length of the building and a full length 12-in. web-plate girder was set snugly against the foundation piers parallel with the street at the lower edge of the footings. This girder was made up of four 4 by 4 by $^1/_2$-in. angles; 12 by 8 by $^1/_2$-in. web plates; and 12 by 24 by $^1/_2$-in. splice plates. A similar girder was placed parallel to it but on the inside of the building, the partition walls or floors that interfered having been removed.

These two girders were then anchored together at the building piers with 1-in. hook rods and 1-in. dowels, as shown in Fig. 2, and the two web-plate girders were completely imbedded in concrete, all being covered with 2 in. of concrete. Thus the toe of each building was anchored to a steel and concrete girder which was then supported from below by concrete piers 4 ft. square, placed every $12^1/_2$ ft. and extending down to sound rock, piling, or the equivalent.

TEMPORARY GAS BY-PASSES AT 42D, 43D, AND 46TH STREETS
Looking North on Eighth Avenue

On the west side of Eighth Avenue from 41st to 42d streets there were old brick buildings founded on shattered rock. These buildings were reinforced in the rear with a "heel" girder similar to the steel concrete "toe" girder at the front. These heel and toe girders were then fastened together by means of 1-in. round rods and turn buckles. After the turn buckles had been tightened until they definitely took tension, the rods and turn buckles were embedded in concrete.

COMPRESSORS INSTALLED IN A BASEMENT

Three electric compressors, each having a capacity of 1,350 cu. ft. per min., and directly connected to a 225-hp. electric motor, were installed in a basement of the southwest corner of 43d Street and Eighth Avenue. Concrete foundation piers were specially constructed to set these motors and compressors on.

Compressed air at 110 lb. pressure was delivered from the compressors through an 8-in. pipe to two 6-in. pipes running the length of the section, each pipe being provided with 3-in. outlets every 90 ft. At first only one 6-in. pipe was run southward from 43d Street under the west curb line of Eighth Avenue to 38th Street. Here it supplied power for digging the original excavation in which the compressed air shovels were set. Later, 6-in. lines were placed on both sides of the street to supply power for the underpinning, and still later the line on the east side of the street was moved to approximately the center line of the structure and a few feet above the main track floor.

EARTH AND ROCK EXCAVATED

Excavation in this section of the subway involved the removal of 318,734 cu. yd. of earth and rock. This work began on February 10, 1926, when the first compressed air was delivered to jack hammers at 38th Street and Eighth Avenue. From the south end of the section, which is 20 ft. south of the south building line of 38th Street and Eighth Avenue, for a distance of 50 ft. northward, earth and rock were excavated to subgrade from net line to net line. This underground room was decked over as it was excavated and timber planking was placed on the floor. The parts of the two shovels used on the job were lowered below the decking and then assembled.

Timber framework was erected on each side of Eighth Avenue and on it were assembled the two telphers. The east and west side telphers began work on May 5 and May 6, 1926, respectively. On those dates the shovels were completely assembled and working, the blasting gangs organized, and the progress of excavation started up Eighth Avenue. Excavation was to proceed at an average rate of 146 ft. per month for 18 months. The telphers were moved in jumps of 20 ft., about twice a week, so that the towers were always resting on transverse girders which were shored up from below by vertical 12 by 12-in. posts.

GAS BY-PASS CONNECTIONS
At Eighth Avenue and 42d Street

While the excavating machinery was being assembled at 38th Street, other excavating work was getting under way. This work preceded the telphers as they advanced northward on Eighth Avenue.

TEARING UP OF SIDEWALKS IS FIRST STEP

Tearing up of the sidewalks was the first step in preparing to excavate. Sidewalks were replaced by decking and sufficient material was removed so that a man could stand upright below the decking. It was also necessary to allow room for the underpinning gang to place the girders along the foundations of the adjacent buildings. This operation was started at 38th Street on both sides of the street and continued the length of the section. Two crawler cranes were used to lift out the buckets of earth. The temporary sidewalk was supported on one side by the underpinning girder at the building line and on the other by a longitudinal girder, upheld from below by cribbing, and running the length of the street, $12^1/_2$ ft. from the building line and just outside the temporary gas pipe, which was put in at this time.

The second area opened up extended from the curb halfway out to the car tracks on each side of the street. On the average, it was excavated to a depth of 8 ft. The rest of the street, out to the car tracks on each side, was then excavated.

It remained only to excavate the area under the car tracks. This operation was carried out by drifting forward from underneath and boxing the entire bed of each car track in a box made of 5 by 2-in. longitudinal

planks. These planks were supported from below by special coped 8-in. H-beams, 4 ft. apart, which rested on the flanges of the two longitudinal girders outside the car tracks, and on the flange of an extra longitudinal girder which was placed at this time in the center between the car tracks.

The four operations which have just been described were done in succession so that, while the area under the sidewalks was being excavated, that adjoining the sidewalks was being excavated a half block to the south, that next to the car tracks a half block farther south, and the earth under the car tracks was being removed 50

UNDERPINNING A 15-STORY BUILDING
Anchors Fasten This Girder to a Similar One Inside the Wall of the Times Square Hotel

ft. south of that. These intervals increased as the work progressed, with the result that the excavation under the sidewalks reached 48th Street in August 1926, while the excavation to subgrade did not reach 48th Street until November 1927.

PUSH CARS USED

At this stage of the work, the entire Eighth Avenue street surface for this section had been removed and replaced with a timber decking supported on seven longitudinal girders, these in turn supported on cribbing. The gallery under the decking was of sufficient depth to allow the men to work with ease. In this gallery, on each side of the street, were placed short runs of narrow gage track, for flat cars carrying buckets or skips. After being loaded with earth, these cars were pushed by laborers to a position underneath shafts so that the buckets could be hauled out by cranes. By this means was removed most of the overburden of earth, which was from 5 to 8 ft. deep. The rock could then be drilled from the top and blasted without hindrance, such as fouling of the drills, by the overlying earth.

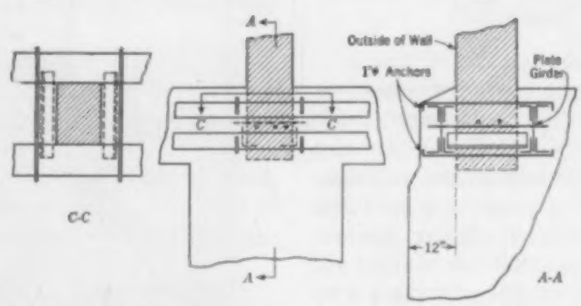
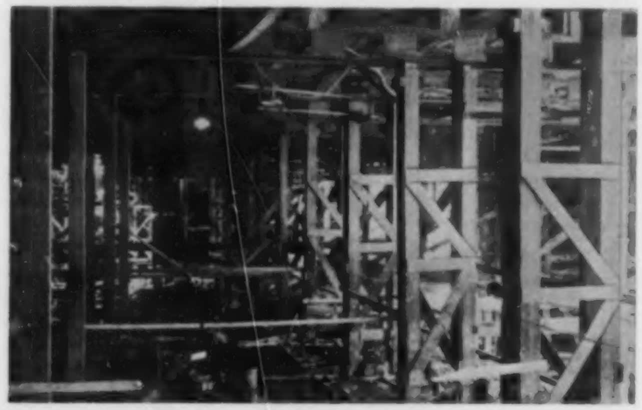


FIG. 2. TYPICAL EXAMPLE OF BUILDING UNDERPINNING
Method of Underpinning the Old Four-Story Brick Buildings on the West Side of Eighth Avenue

Traffic along Eighth Avenue being completely carried on timber decking, the remaining excavation was done from below and the rock and earth were carried to the street in 2-yd. skips by the telphers, Fig 3. Excavation of the lower level track was done by a separate gang which worked from a block and a half to three blocks behind



UNDER EIGHTH AVENUE LOOKING SOUTH
South Building Line of 42d Street, June 1927

the main heading. The 2-yd. skips of rock were carried from the rear heading to shafts by means of an electric monorail, and from thence to the street by a crane.

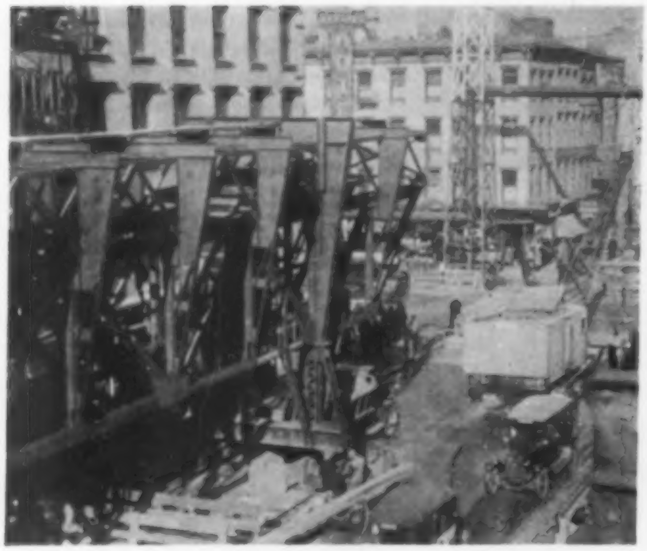
On December 3, 1927, or 19 months after the telphers started their northward march, they had been dismantled and completely removed from the job. All excavation had been completed except minor trimming at side streets and station entrances.

On the west side of Eighth Avenue, from 40th Street to 44th Street, the net line of the subway was on the building line. On this line, a sheer rock cut of 50 ft. necessitated line drilling, the holes being spaced 5 in. apart. The rock was fractured to such an extent that it had to be doweled with three parallel horizontal rows of holes 10 ft. apart, the dowels in each row being placed 3 ft. apart. In each hole a $1^1/_4$-in. steel dowel from 5 to 15 ft. long was grouted, thus holding the fractured rock together and preventing slips.

Seven continuous built-up girders, 32 in. deep and weighing 140 lb. per lin. ft., were placed the entire length of this section. There was one in the dummy between the car tracks, one to the east of the uptown track, one to the west of the downtown track, one at each curb line, and one on each side of the street, halfway between the curb line and the car tracks. These continuous longitudinal girders were laid directly on similar 32-in. girders placed crosswise of the street every 20 ft. For the entire section, 31,970 ft. of these built-up sectional girders were used. Typical supports for the transverse girders are illustrated in Fig. 4.

SPECIAL BRACING REQUIRED

In the case of the rock wall on the west side of Eighth Avenue, from 40th to 44th Streets, where it had to be



TELPHER LOADING A TRUCK WITH EXCAVATED MATERIAL

braced to prevent its slipping into the cut, a system of lateral bracing every 20 ft., as shown in Fig. 4, was built up as the excavation advanced. This bracing was carried forward by a special gang of timbermen who were detailed to keep it continually inspected. In the buildings above the wall that was braced in this manner settlement was infinitesimal. The 32-in. transverse built-up girders were wedged at each end against the footings of the adjoining buildings and were supported in the center by a tower of four 12 by 12-in. timber posts braced together, and on the west half by two posts of three 6 by 12-in. timbers bolted together, one near the wall and one between the wall and the center tower.

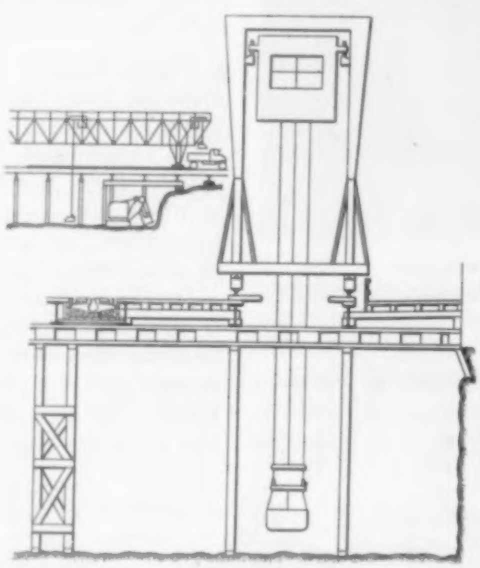


FIG. 3. DIAGRAM OF A TELPHER

While the center tower rested directly on the rock floor of the excavation, the two posts of built-up 6 by 12-in. timbers rested on a needle made of similar timbers bolted together and extending from the rock wall to the center tower. The vertical posts, made up of three 6 by 12-in. timbers, rested on the horizontal needle made up of two similar timbers in such a way that one of the vertical timbers lapped over and was bolted to the side of the needle. The foot of the center tower was also braced by small 12 by 12-in. timbers leading into a niche in the rock floor.

The needle was supported from below by cribbing on the berm, by two vertical 12 by 12-in. posts, and by two inclined 12 by 12-in. braces arranged in such a way that the vertical posts could be shot away without endangering the wall.

The two vertical posts, each made up of three 6 by 12-in. timbers bolted together, were braced laterally by a 12 by 12-in. timber on a 45-deg. angle, leading into the edge of the berm. The cleats used on top of and underneath the horizontal needle were 4 by 12-in. planks spiked down.

These vertical posts were braced together near their tops by a horizontal 12 by 12-in. timber under the built-up girder, while the vertical post, between the center column and the post near the wall, was caught against the bottom of the built-up girder by an angle riveted to the girder. Each of the built-up posts was supported from the under side of the horizontal girder so that, if the braces were shot away, the posts would still be left hanging from the beam above.

To support the rock wall, rows of horizontal rafters composed of three 4 by 12-in. timbers bolted together were held in place by vertical 6 by 12-in. timbers set against the vertical post previously described. The rafters had 10 by 10-in. horizontal rangers butting against them and these supported 5 by 10-in. vertical wales with 2 by 12-in. horizontal sheeting against the rock wall, all as shown in Fig. 4.

DETAILS OF DECKING

Blocking was placed on the lower flanges of the longitudinal girders on which rested 12 by 12-in. transverse timbers at 5 ft. on centers, extending through the openings in the longitudinal built-up girders. Timbers, 10 by 10 in., 2 ft. 6 in. on centers, and parallel with the street, were placed on the 12 by 12-in. timbers. On top of these was laid the 5 by 12 and 5 by 10-in. decking, which bore the street traffic.

On their lower flanges, the longitudinal girder in the dummy between the car track, and the two on each side of the car tracks, carried a framework of 6-in. transverse H-beams spaced 4 ft. apart. These beams carried boxes composed of 5 by 2-in. longitudinal planks in which were yokes and foundations for the trolley tracks.

Throughout, this decking was fabricated with hand labor without the use of cranes. It could be laid down without opening up at any one time an excessive area of the street, a length of 20, 30, or 40 ft. being sufficient, depending on the length of the angle to be used in fabricating the longitudinal girders. As the space from the building line to the center line of the street was opened up in successive steps, it was not necessary at one time

HEAVY TRAFFIC ON EIGHTH AVENUE DURING CONSTRUCTION

to work on more than one-quarter of the width of the street.

In this system of decking, longitudinal bracing was provided by the roadway and by the seven continuous longitudinal girders. It had such strength and rigidity that it allowed unusual freedom of operation and provided abundant clearance for excavating in clear and unobstructed spaces as great as 40 by 100 ft.

Except for the 48-in. water main across Eighth Avenue at 42d Street, decking supported all the numerous subsurface structures as well as the street traffic. When loaded, the water main weighed 1,660 lb. per lin. ft. and was supported by two extra 32-in. built-up girders placed below and parallel to it. Through the open panels of these extra girders, 15-in. I-beams were placed every 10 ft., and on these the main was blocked up with timber blocking.

STEEL ERECTION METHODS

Structural steel for this section was stored in the Pennsylvania Railroad Company's yard on the Newark meadows and shipped to the job by scows. The pieces were numbered and piled on the decking along the curb line in a marked position so that, even when covered with snow, each piece could be located immediately as it was needed.

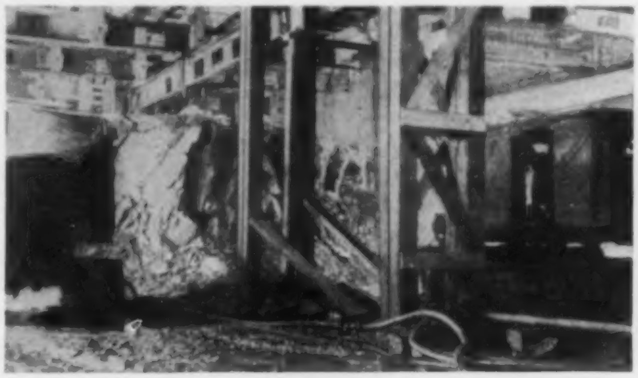
The various steel members were lowered into position, through holes in the decking, by the two cranes. The 3-ton girders that span the Queensboro Subway at 41st Street were lowered into the cut by means of an especially constructed A-frame. Over a period of $15^1/_2$ months, an average of 38,377 tons of steel were set per month. Traffic conditions limited the size of shipments, deliveries being made each week.

It was found that the steel roof beams under the Eighth Avenue–38th Street intersection could not be set because of interference by subsurface structures, such as water pipes, telephone cables, and mail tubes. No amount

Crane Removing Earth from the First Cut
Timbermen Laying Decking in the Foreground

of manipulation of these subsurface structures would allow the roof beams at 38th Street to be set. It was necessary for the telephone cables running east and west and north and south on the east side of the street to be by-passed into temporary positions through holes that were left in the roof and sides of the subway structure.

As shown in the accompanying progress chart, Fig. 1, this same condition prevailed at 40th, 41st, and 42d streets. The bents of steel had reached from 38th Street to 42d Street before the last riveted roof beam had been set at 38th Street and, 13 months later, there were still 4-in. I-beams to be placed in the bottom of depressed bays at 38th Street. This condition slowed up succeeding steps of the work, such as waterproofing, completion of duct lines, backfilling, and paving. These in turn caused interference in street traffic due to open



Compressed Air Shovels and Traveling Longitudinal Girder

holes in the decking, an excessive lapse of time before backfilling could be performed, and an increased payroll due to men having to repeat their duties in patching up a job which should have been performed in a continuous manner without breaks.

Immediately after the permanent steel was erected, blocking was placed between it and the longitudinal decking girders. The vertical 12 by 12-in. posts and the timbering on the west side of Eighth Avenue were removed, thus transferring the load of the decking and the pressure of the side walls to the permanent steel. As soon as this was completed, the transverse decking girders were taken out.

PLACING THE CONCRETE

About 70,000 cu. yd. of concrete for Sections 4 and 6 of Route 102 were mixed in a central mixing plant at West 50th Street and the North River. The concrete mix was 1:2:3.85. The aggregate was delivered to this central mixing plant in 5-ton trucks, hauled up a ramp and dumped into the boot of a conveyor belt about 40 ft. high, discharging into a 200 and a 400-yd. storage hopper. Hand trucks were used to transfer the cement from barges to the storage shed which was alongside the dock.

From the storage shed, which had a capacity of 12,000 bags, it was loaded on a 24-in. belt conveyor about 100 ft. long that delivered to the charging platform of the two 1-yd. mixers. Above the charging platform were the measuring valves for the aggregate and an inundator which accurately regulated the water content in the concrete. The two mixers, which were operated alternately and continuously, had a record of 400 batches in one 8-hour shift, and a delay for mixer repairs of only 24 hours in two years. A total force of six men in summer and nine in winter was employed.

In winter the mixing water was taken from two boiler feedwater heaters operated by an 80-hp. boiler with an extra large firebox in which refuse wood was burned. This heated the water to 140 deg. fahr. at the mixer,

while the condensed steam passed through coils in the aggregate bins and then heated the mixing room before returning to the boiler.

The cement bags were placed on the conveyor belt in groups of seven, the amount required for a single batch. The conveyor was started and stopped by a man on the mixer platform who untied the bags and emptied them into the charging hopper. Another man on the mixer

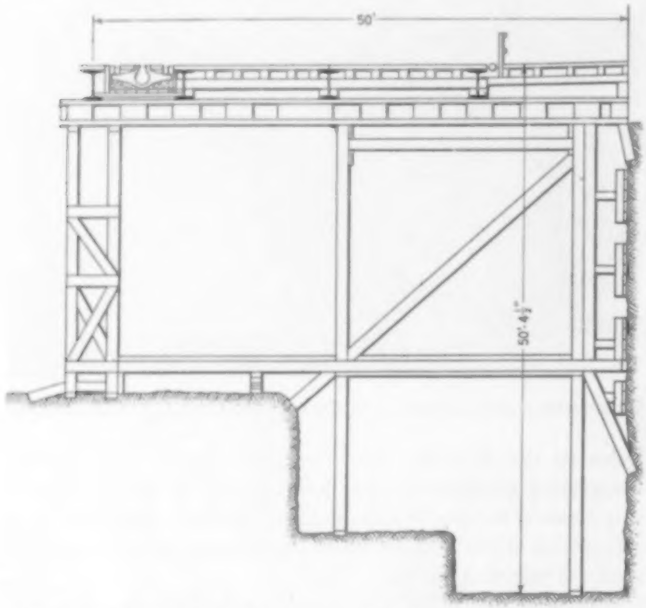


FIG. 4. TYPICAL CROSS SECTION OF TIMBERING AND DECKING

platform operated four levers controlling the gravity discharge of aggregate from the bins, the inundator, the charging valve shifting the contents of the hopper to either mixer, and the discharging lever that dumped the concrete into the trucks.

At the subway, the trucks discharged directly into chutes to the forms, thus placing the concrete in the form in less than 20 minutes after mixing. Each truck made a maximum of eight round trips per eight-hour shift. The central mixing plant was so well equipped for cold weather service that in zero weather it mixed concrete which was successfully placed in the forms two miles away at a temperature of 70 deg. fahr.

RESTORATION OF SUBSURFACE STRUCTURES

The logical method of restoring the subsurface structures that were located between the roof of the subway and the street surface would have been to wait until the roof of the subway had been waterproofed and covered with protection concrete, and then open up the street decking, backfill, build the new subsurface structures and pave the street.

In the case of Eighth Avenue from 38th to 42d streets this was impossible because there were 16 holes through the subway structure leading by-passed cables into and out of the mezzanine floor. These by-passed cables had to be so placed because there was no other way of maintaining them and at the same time building the steel and concrete roof of the subway. It was impossible to restore these underground structures in a normal sequence because traffic conditions forbade the opening up of any considerable area of decking at one time.

In many instances the new subsurface structure had to be built in the location occupied by the old structure or by the cables which had been contained in the old structure. This meant duplication of effort in handling practically all the cables on the job.

It was realized by the members of the firm that it would be impossible to close up the roof of the subway, backfill, and pave until all the by-passed cables had been removed from their paths through the subway structures. These by-passed cables could not be removed until the new subsurface structures had been finished, new cables drawn through them, and the live splices completed. Every effort was then made in the sector between 38th Street and 42d Street to move the cables out of their temporary positions, erect the new subsurface structures, pull in the new cables, make the live splices, pull out the dead cables that led through the holes in the subway structure, patch up the holes, waterproof, backfill and pave the street. After completing these final details, traffic was again allowed to flow freely through this crowded section.

In restoring duct lines it was found best to open up the decking above the place where the manholes were to be built, build the manholes, build as much of the duct lines as possible under the decking, then remove the decking between the manholes, complete the duct lines, backfill, and pave.

The water mains and the underground power supply of the street railways were supported, before removing the decking, by concrete piers. The permanent gas mains were laid at the time of backfilling. Below 42d Street they were connected up at every block, while above they were connected at every other block. The sewers were restored as soon as the roof of the subway permitted and, where possible, they were opened for use as soon as restored.

ACKNOWLEDGMENTS

The work was designed and conducted under the supervision of the Board of Transportation of the City of New York: Robert Ridgway, M. Am. Soc. C.E.,

TANGLED MASS OF CABLES
Southeast Corner of 41st Street and Eighth Avenue

LIVE CABLES RAISED ABOVE THE STREET
Backfill Below

Chief Engineer; J. R. Slattery, M. Am. Soc. C.E., Deputy Chief Engineer; Sverre Dahm, M. Am. Soc. C.E., Deputy Chief Engineer in charge of design; and R. Fiesel, Section Engineer. The contract was carried out by Frederick L. Cranford–Charles H. Locher, Inc.; Mr. Cranford and Mr. Locher, both Members Am. Soc. C.E., gave it their personal supervision. The secretary of the company was Frederick Ward and the Chief Engineer, James C. Meem, M. Am. Soc. C.E.

Constructing the Detroit-Windsor Tunnel

Current Practice in Subaqueous Tunnels

By S. A. Thoresen

Member American Society of Civil Engineers
Engineer of Designs, Parsons, Klapp, Brinckerhoff and Douglas, New York

Subaqueous tunnels have challenged the resourcefulness of the engineer since early in the nineteenth century. Compressed air, cast-iron tunnel linings, and the use of the one-piece driving shield have overcome most construction difficulties. Since the advent of the motor vehicle, tunnel ventilation has been a vital problem. In the Detroit-Canada International Tunnel, finished in 1930, use was made of the latest developments in the construction of tunnels of this character. The river section was built of 250-ft. steel tubes, 31 ft. in diameter, sunk into a dredged trench in the river bottom, joined together under water, jacketed and waterproofed with concrete placed by tremie, lined with reinforced concrete, and finished with enameled steel tile. This paper was presented by Mr. Thoresen before the New York Section of the Society at its meeting on December 17, 1930.

The history of subaqueous tunnels dates back to the year 1818, when Marc Brunel took out the first patent for the shield and cast-iron lining. About 12 years later, or in 1830, Sir Thomas Cochrane secured the first patent for the use of compressed air. Between 1825 and 1843, Marc Brunel built the first subaqueous tunnel under the Thames and, due to his genius, it was finished under the most difficult conditions without the use of compressed air. But this ambitious enterprise was a financial failure and checked all other undertakings of similar character for the next 25 years. It was not until James Henry Greathead developed the circular one-piece shield, invented the grouting machine, made use of compressed air, and introduced cast-iron lining, that subaqueous tunnels were economically built.

The first vehicular tunnel of magnitude and capacity was the Blackwall Tunnel in London, opened for traffic in 1897. Other tunnels were the Glasgow Harbor Tunnel, the Elbe Tunnel, and the Rotherhithe Tunnel, the last completed in 1908. All these were built previous to the advent of the automobile.

Since the automobile came into general use, the following tunnels have been built: the Holland Tunnel under the Hudson River, the Liberty Tunnel in Pittsburgh, the George A. Posey tube between the cities of Oakland and Alameda, and the Detroit and Canada Tunnel under the Detroit River. These four tunnels were finished during the last decade.

Late in the year 1926, or practically four years ago, a gentleman entered the offices of Parsons, Klapp, Brinckerhoff and Douglas. He presented the idea that a vehicular tunnel between Detroit and Windsor, Canada, would be not only feasible but also profitable from an investment point of view. After a lengthy analysis, weighing both sides of the question, the conclusion was reached that a vehicular tunnel financed by private capital would render sufficient return to pay interest on the investment. A group of Detroit bankers, aided by New York and Chicago banking houses, subsequently took over the financing and engaged the firm of Parsons, Klapp, Brinckerhoff and Douglas as engineers for the design and supervision of the work.

There is an interesting side to the early history of this tunnel project—the promoter was a captain in the Salvation Army. When the project was in an embryonic stage, he was beating a drum at meetings for the remunerative salary of $25 a week. To such prosperity was added unbounded confidence in himself and in the project, and this was needed to carry the idea over its initial hurdles. Engineers, who are modest in their demands, may be interested to know that this original promoter received quite a handsome remuneration for

Fig. 1. Location Plan

his early efforts without having the slightest knowledge of the intricate technical problems involved in tunnel construction.

THREE TYPES OF CONSTRUCTION

The Detroit and Canada Tunnel connects the downtown business section of Detroit with the center of the business section of Windsor. The terminal plaza in Detroit is bounded by Woodbridge, Randolph, Atwater, and Bates streets, and in Windsor by Ouellette, Wyandotte, Goyeau, and Park streets. Its general relation to the two cities is shown in Fig. 1.

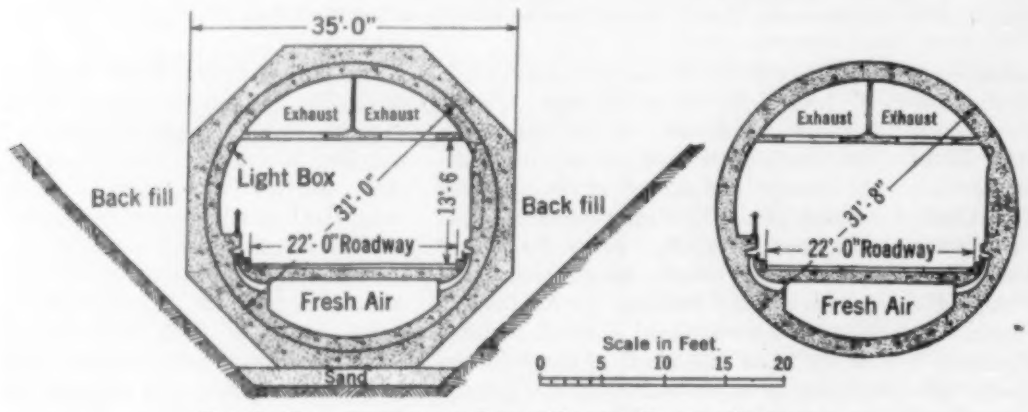


FIG. 2. SUBAQUEOUS AND SHIELD-DRIVEN TUNNEL SECTIONS

Built for the purpose of accommodating the steadily increasing automobile traffic between the two communities situated on each side of the Detroit River, this tunnel is destined to become one of the major motor arteries between the United States and Canada. It is 5,137 ft. long between portals, or about 5,800 ft. between street grades. The roadway is 22 ft. wide, allowing for two lanes of traffic in opposite directions, with sufficient marginal width to pass a third car in case of an emergency breakdown. The estimated capacity per lane of mixed traffic of passenger cars, buses, and trucks is 1,000 vehicles per hour, or 2,000 cars in both directions, this capacity being more or less dependent upon the customs and immigration facilities at either end of the tunnel. The maximum grade is 5 per cent, and the clear headroom is 13 ft. 6 in. On one side a sidewalk is provided for patrol purposes.

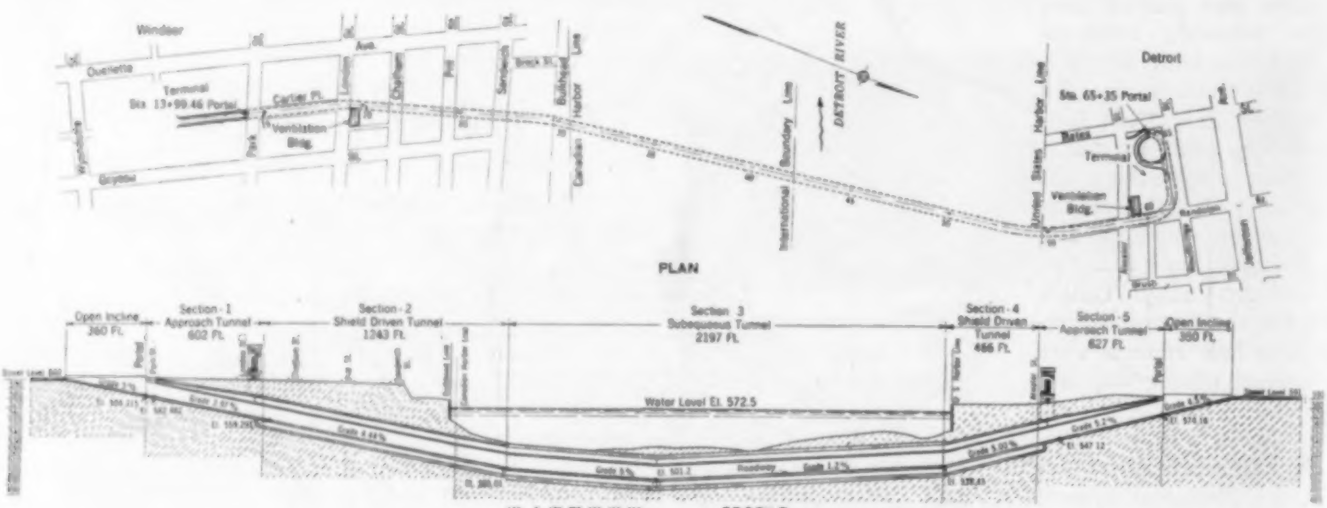


FIG. 3. PLAN, PROFILE, AND CROSS SECTIONS

For designing and construction reasons, the work was subdivided into five sections as shown in Fig. 3: the first constituting the subway section in Windsor, about 600 ft. long; the second, the shield-driven section in Windsor, about 1,243 ft. long; the third, the trench-and-tremie section across the river, about 2,200 ft. long; the fourth, the shield-driven section in Detroit, about 467 ft. long; and the fifth, the subway section in Detroit, about 627 ft. long. Three distinct types of construction were involved in this work.

Other major items include the two terminal plazas, with all facilities for customs and immigration inspection, and two ventilation buildings, one in Detroit and the other in Windsor, with complete mechanical and electrical equipment for purifying the air in the tunnel.

THE APPROACH SECTION

The approach part of the tunnel was designed as a box subway of the conventional type, using steel bents on 5-ft. centers, joined together by concrete jack arches. The structure was built by the cut-and-cover method, with steel sheet piling and timber shoring. It was waterproofed by the membrane method and backfilled in the usual manner. As shown in the cross section, Fig. 4, the air ducts were placed above the ceiling with fresh air flues spaced at frequent intervals and brought down to the level of the roadway.

In connection with the shield-driven part of the

tunnel, the distinguishing feature is that structural steel was used for the primary lining instead of cast iron, the material which has been in general use for the last 60 years. Before adopting the pressed steel lining, several alternate designs were prepared, based on wood, built-up structural steel, and cast iron. In view of the fact that economy, combined with lightness, ease of erection, and adequate strength, were the determining factors in producing a tunnel that could be financed by private capital, the type of lining as finally adopted actually met all requirements.

The tunnel itself is circular in section, with an outside diameter of 31 ft. 8 in. After the erection of the primary lining, a secondary lining 22 in. thick, of reinforced concrete, was added for strength and finish. The shield used for driving the tunnel had a diameter of 32 ft. $3^{3}/_{8}$ in. and an over-all length of 15 ft. $3^{1}/_{2}$ in. It weighed about 275 tons and was propelled by 30 jacks of 150 tons capacity each. The maximum air pressure used during the operation was only 20 lb. per sq. in., and the maximum progress made during 24 hours was 20 ft., which is a record for a bore of such magnitude.

Stiff gray clay was the material through which the shield was driven, and it was excavated with drag knives operated by small electric hoists on the platforms of the shield, the workmen dumping the spoil into chutes, which delivered it to belt conveyors discharging into mucking cars, as illustrated in Fig. 5.

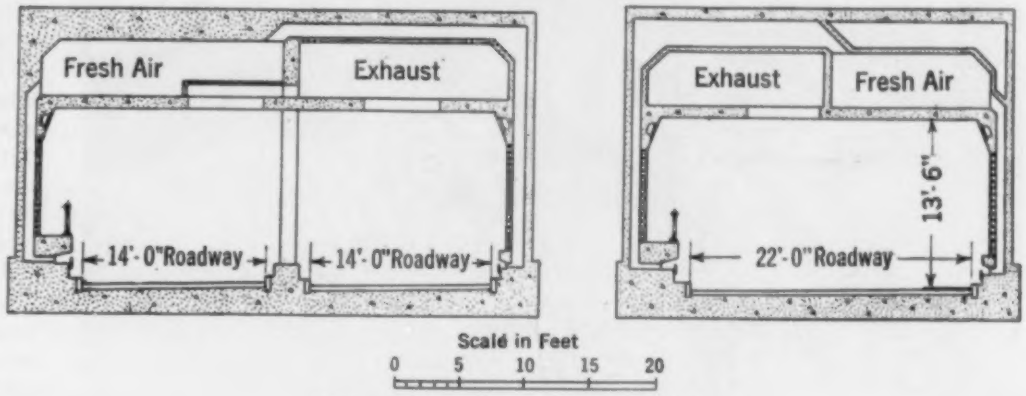
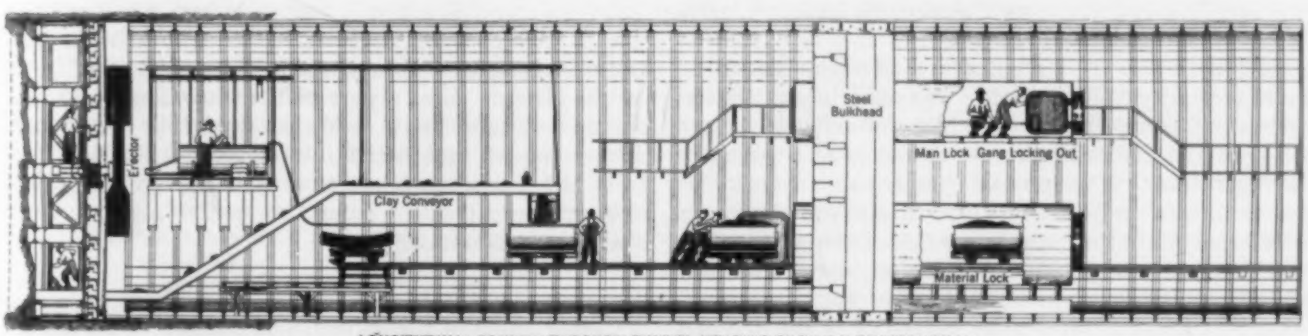
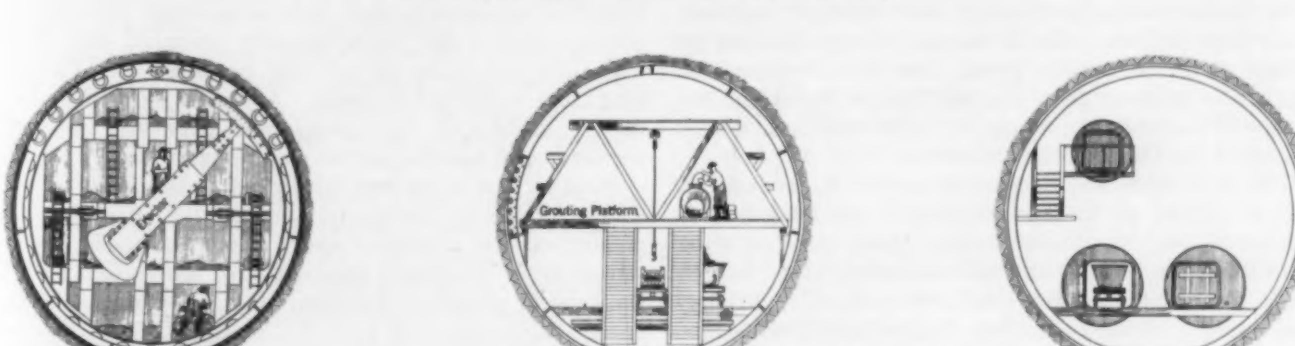


Fig. 4. Approach Tunnel Sections



LONGITUDINAL SECTION THROUGH TUNNEL HEADING SHOWING CONSTRUCTION OPERATIONS AND INSTALLATION OF PRESSED STEEL LINING



REAR VIEW OF SHIELD

FRONT VIEW OF GROUTING PLATFORM AND CLAY CONVEYORS

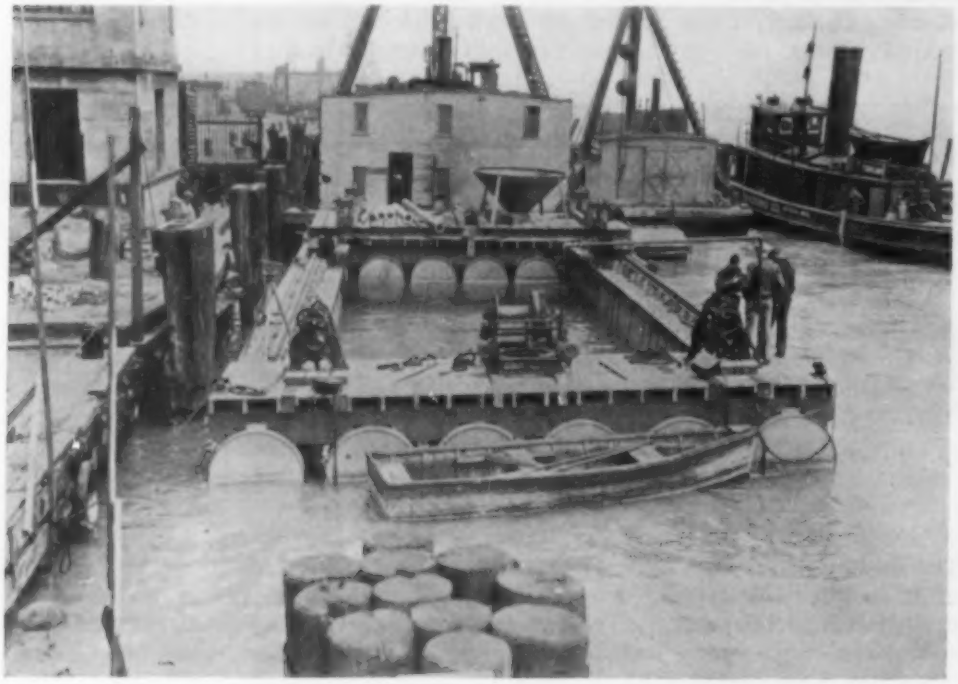
INSIDE VIEW OF BULKHEAD AND AIR LOCKS

Fig. 5. Driving the Shield—Installing the Lining
Graphic Illustration of Operations in the Air Lock

PRIMARY LINING OF STEEL PLACED BY ERECTOR

The circular ring of the primary lining consists of 11 segments and one key. Each segment was pressed from $^{3}/_{8}$-in. plates into the shape of a pan, having a length of 9 ft. measured along the circumference, and a width of 2 ft. 6 in. over the flanges. Reinforcing angles were welded

to the 10-in. circumferential flanges. Short I-beam stiffeners were welded between the flanges for the purpose of resisting the thrust from the shield jacks. Each segment weighed about 1,000 lb. and required 32 ft. of bead welding.



SAND PLACING AND LEVELING MACHINE

Steel used for the lining was mild open hearth of pressing quality. The pressing was done in a 1,500-ton mechanical press, the die of which formed the flanges and bent the plates lengthwise to the proper radius in one operation. The pressed plate was trimmed to correct dimension both as to length and angularity, in order to maintain the diameter and circumference.

In order to secure perfect bearing against the flanges, the I-beam stiffeners were cut with great precision, either by a shaping saw, or by means of a die. When all the component parts had been assembled, they were welded together. After each welded segment was completed, the holes in the flanges were pierced by means of an automatic punch and the segment was tapped for a grout pipe. As an illustration of the accuracy of the work, the actual circumference came within $^3/_{32}$ in. of the theoretical circumference.

The steel lining was designed to sustain 45 ft. of liquid clay at 135 lb. per cu. ft., and that it was subjected to this pressure was demonstrated during the grouting process. At a point where the maximum cover was 43 ft., a three-story building was raised about 1 in., thus the lining sustained the full hydrostatic pressure of liquid grout equivalent to a 50-ft. head. As a comparison of weight between steel and cast iron for this particular tunnel, the weight per linear foot for steel was 2.35 tons, while for cast iron it was estimated to be three times as much, or about 7 tons.

ONLY SLIGHT DISTORTION EXPERIENCED

During erection, the steel lining fulfilled all requirements according to the theoretical assumptions and, although slight distortion was experienced from the start, conditions improved as the work progressed. As a matter of fact, steel lining used in clay may be considered a superior product for large shield-driven tunnels.

Based on current prices for tunnel construction material, it is safe to say that considerable saving is effected by substituting steel for cast iron in soil similar to the Detroit clay. The interior concrete lining was poured by using movable steel forms in 4 by 4-ft. panels, while the arch and the ceiling slab were poured by the use of collapsible steel forms.

Junction between the shield tunnel and the trench-and-tremie tunnel was effected by driving the shield into the bell-ended river tube next to the shore. This operation was performed under a clay blanket that was dumped in advance, the shield being pushed blind through the blanket. After the shield had entered the bell and the cutting edge had made contact with the steel diaphragm of the river tube section, the skin plate of the shield was left in place to form a part of the tunnel, while the interior structural parts and the hydraulic equipment were removed and fitted into a second shield driven from the Canadian shore toward the river. Considerable economy resulted from this method, as two river shafts were eliminated.

TRENCH-AND-TREMIE TUNNEL

Construction of the subaqueous portion of the tunnel was effected by dredging a trench along the river bottom. Into this was sunk a steel tube completely jacketed in concrete and resting on a specially prepared sand bed. The tube was made up of nine sections, one 220 ft. long, and eight 248 ft. long. A special joint of simple design facilitated the connection between adjacent segments and speeded up the sinking process.

Steel for the tubes was fabricated at the plant of the Canadian Bridge Company, Walkerville, Ontario, and erected on the Canadian shore about six miles downstream from the tunnel location. An illustration shows the tube in process of erection. It has a diameter of 31 ft. and is composed of plate $^3/_8$ in. thick. The circumference is divided into quadrants with all longitudinal seams butt-welded and all circumferential seams single-lap riveted.

At intervals of 12 ft., octagonal diaphragms were riveted to the shell plate, serving a twofold purpose, to stiffen the tube and to support the timber forms for the concrete jacket. For further stiffening, ring angles were added on the inside of the tubes. These were spaced 4 ft. on centers and punched to receive the rod reinforcement for the interior concrete lining. The reinforcement

Erecting One of the Subaqueous Tubes
Forms Are Attached to Diaphragms

Pouring Concrete Around a Tube
Prior to Sinking

A Tube Ready to Sink
Aligning Tripods in Position

consisted of two concentric rows of longitudinal rods joined by stirrups, and of circumferential hoops spaced 12 in. on centers.

The tubes were erected on launching ways made up of two 12 by 12-in. timbers supported on piles, having an inclination of 1 to 10. The tubes rested in cradles and the launching was controlled by winches, blocks, and tackle. The tightness of all joints was tested by applying liquid soap to one side and compressed air to the other, leaks being indicated by the formation of bubbles.

Designed to sustain a load of not less than 1,500 tons, the watertight bulkheads which sealed the ends of the tube consisted of horizontal and vertical trusses and steel beams. Against the steel framing rested 10 by 10-in. timbers, and at right angles to these was placed ship-lap $^7/_8$ in. in thickness. On the ship-lap an 8-ply waterproofing was applied and properly flashed to the steel shell. Before launching, all the steel reinforcement was in place, and some ballast was added in the bottom of the tube in order to make it stable after launching. The total weight of the tube on the ways was about 500 tons, and the draft after launching was 7 ft.

SPECIAL MACHINE PREPARES SAND BED

Previous to the sinking operation, a sand bed had to be prepared in the bottom of the trench. The sand was placed to correct grade by use of a specially designed leveling device, consisting of a hollow rectangular raft of steel pontoons 70 ft. long, joined together by four shorter pontoons at each end. Rails were placed on top of the long pontoons, and a special carriage, operated by winches, traveled back and forth over them, carrying a frame made of steel beams, which acted as a sweeper for the sand bed.

After the raft had been spotted over the trench, the sand was lowered into it by means of clamshell buckets. Four anchors located at each corner of the raft held the sanding device in position. By pulling the wires taut, the raft was submerged an additional 6 ft. over the normal buoyancy, thus eliminating movement due to wave action from passing steamers. The success of sinking the tubes both as to grade and alignment was largely due to the development of this ingenious device, by which the sand bed was placed with great accuracy.

SINKING THE TUBES

Following the launching, the tube was towed to a fitting-up slip where the interior concrete lining, the floor slab, and the keel of the tube were poured, using removable steel panels for forms. The exterior form work was then erected and, with the added weight, the tube had a draft of 23 ft., equal to the maximum depth of water in the slip. In this condition, the tube was towed upstream to a point approximately 300 ft. above the tunnel trench. It took four tugs about three hours to tow the tube six miles against a two-mile current. The tube was then moored to five pile clusters where the balance of the tremie concrete was poured. For this purpose, the contractor employed a two-masted scow provided with flexible-tube concrete chutes. Particular care had to be exercised in keeping the tube on an even keel during pouring.

A noteworthy departure from previous practices was the method of sinking. The placing of the tremie concrete described above was stopped just as the tube was awash. The next step was to place four 5-ton concrete blocks on one end of the section so as to completely sink that end. This condition brought the top of the tube 4 or 5 ft. below the water surface. A buoyancy scow was then placed over it at right angles to its axis, and cables were connected to it so that it could be raised or lowered from the scow. Next, the other end was similarly lowered and a buoyancy scow placed over it and properly fastened. The section was then raised to the surface, ready to be towed to a position over the prepared trench and lowered into place.

It was a difficult problem to handle the tube, which displaced about 8,000 tons of water when completely submerged, and was subjected to a pressure of approximately 50 tons due to current velocity. Twice the contractor lost control of the tubes but, although some loss of time resulted, no damage was done.

The joint between two adjacent tube sections consisted of a protruding lip plate on the lower half of the section first sunk. The section to be joined had a similar protruding lip on the upper half. Cast steel lugs were riveted to the shell plate near the horizontal diameter on opposite sides, one pair to the upper half and the other pair to the lower half.

By means of a 5-in. pin dropped into corresponding holes, as shown in Fig. 2, the sections were joined together quickly, flexibility being accomplished by making the holes in the lower castings slotted. The joint was rendered watertight on the outside by tremie concrete, and on the inside by a specially designed structural joint filled with grout and by the 18-in. reinforced concrete interior lining. After the joints were finished, the entire tube was backfilled with clay, allowing a minimum cover of 4 ft. above its top.

RESEARCH DEVELOPS VENTILATION SYSTEM

Although modified to meet local conditions, the system of ventilation designed for the tunnel is based upon the research work and equipment details as developed by the engineering staff of the Holland Tunnel in cooperation with the U.S. Bureau of Mines. There are two ventilation buildings, one on each side of the river. In each building 12 fans are installed, one-half of which are blowers, and the other half exhausters.

DETROIT VENTILATING BUILDING

Fresh air enters the fans through louvered openings in the side of the building, and is forced down through vertical ducts to the semicircular duct beneath the roadway. The maximum carbon monoxide content is limited to 4 parts in 10,000. The combined capacity of all fans is about 1,000,000 cu. ft. of air per min., and the largest fans have a capacity of 195,000 cu. ft. per min.

At intervals of 15 ft., the air escapes through curved flues into expansion chambers and sweeps across the roadway, through a continuous slot, in this way diluting the motor exhaust gases. From the roadway, the vitiated air is drawn through openings into the ceiling exhaust duct, from which it makes its escape through the exhaust fans and into the open air by means of vertical stacks. Provision is made for 45 changes of air per hour. During the maximum congestion on the first Sunday, when cars passed through at the rate of 2,000 per hour, the carbon monoxide content was less than 2 in 10,000, which speaks well for the efficiency of the system.

Power comes from three substations in Detroit and from two in Canada, thus giving adequate protection in case of an emergency.

TERMINAL PLAZAS AND BUILDINGS CONSTRUCTED

Owing to the international character of this tunnel, a comprehensive plan was necessary to provide for the accommodation of customs and immigration officials, for the tunnel administration, and for bus and emergency equipment. In all, about 25 buildings of major and minor size were built to meet all requirements.

With maximum traffic, eight lanes for customs inspection on the American side and ten on the Canadian side are operated to capacity. Bus passengers are discharged at either terminal and, after having passed the usual routine inspection, are admitted to the street. "Snoop" lights in the pavement have been installed on the American side to aid the customs inspectors in detecting concealed contraband.

Buses operating exclusively through the tunnel are of the twin-coach type providing a de luxe service between the two cities equal to the best in the country.

PRIVATELY BUILT, OWNED, AND OPERATED

Appraised at a value of $23,000,000, the tunnel was financed by the Guardian Detroit Company, associated with banking houses in New York and Chicago. It is the first international vehicular tunnel, and one of the few to be privately financed, privately built, and privately operated.

INTERIOR OF THE COMPLETED TUNNEL

The period during which the tunnel was constructed covered 29 months. The general contract for the shield and river portion was executed by Porter Brothers and Robert Porter, of Spokane, with the Northern Construction Company of Montreal as subcontractors. The contract for the subway approaches, the ventilation buildings, and the terminal plaza structures was executed by the Parklap Construction Corporation, with Frank W. Barnes, M. Am. Soc. C.E., in charge. The Windsor approach and the substructure of both ventilation buildings were sublet to Spencer, White and Prentis. The Detroit approach was executed by the Mark R. Hanna Company.

In charge of design and supervision was the firm of Parsons, Klapp, Brinckerhoff and Douglas, with Burnside R. Value as executive engineer. I was engineer in charge of design; William C. Dunlop was engineer in charge of electrical and mechanical equipment; Vincent Macaluso was in charge of all field engineering; Wilson S. Kinnear, M. Am. Soc. C.E., as consulting engineer, represented the banking interests; and Ole Singstad, M. Am. Soc. C.E., was general consultant on the project, especially in connection with the ventilation. From start to finish all operation was directed by Eugene Klapp, M. Am. Soc. C.E., of Parsons, Klapp, Brinckerhoff and Douglas, and due credit is hereby given to him for the harmonious relation existing between the tunnel company, the United States Government, the Canadian Government, the engineers, and the contractors, resulting in the completion of the project in the shortest possible time.

Photographic Surveys of Hoover Dam Site

Photo-Theodolite and Stereoscopic Pictures Solve Difficult Mapping Problem

By C. H. Birdseye

Member American Society of Civil Engineers
President, Aerotopograph Corporation of America, Washington, D.C.

Because of the need for extremely accurate topographic maps of the walls of Black Canyon at the location of the dam, power house, diversion tunnels, and cofferdam structures, and because of the extreme inaccessibility and precipitousness of the site, the Bureau of Reclamation, after considering aerial and other methods of obtaining topography, determined upon the use of the photo-theodolite from ground stations as the only practicable means of securing the desired result. How Colonel Birdseye's company proceeded with this unusual survey under adverse desert conditions and subsequently plotted the results by use of the aerocartograph instrument, will prove enlightening.

PRELIMINARY surveys for the investigation of the possibilities of impounding water in the lower canyon area of the Colorado have been in progress for ten years or more and, during this time, the Bureau of Reclamation acquired data as to available dam sites and reservoir capacities which enabled it to select the most suitable site for a high dam in the lower canyon region. A site was finally selected in Black Canyon, where the canyon walls afford as good a cross section as in Boulder Canyon, and sub-surface conditions are somewhat better. Hoover Dam is therefore to be built in Black Canyon, although the project is still called the Boulder Canyon project. Other details of this tremendous project were described by Elwood Mead, M. Am. Soc. C.E., Commissioner of Reclamation, in the October 1930 issue of Civil Engineering.

Specifications Issued by the Bureau

When Congress passed the Boulder Dam Act and the subsequent act making the initial appropriation, the Bureau of Reclamation had already made all the preliminary surveys and had decided on the general plan. There remained, however, the necessity of topographic surveys for construction purposes. The Bureau decided to contract for this work and specifications were issued on June 3, 1930, covering four main items, all involving the use of some form of photographic mapping.

The first requirement was for a controlled aerial mosaic of about 250 square miles of valley area above Yuma, for the All-American Canal diversion, to a scale of 1 in. = 1,500 ft. Second, the specifications called for a topographic map of about one-half square mile at the Hoover Dam site, including a stretch of the river about 2,500 ft. above and below the actual site, and extending to the 1,375-ft. contour, to a scale of 1 in. = 50 ft., with a contour interval of 5 ft.

Third, a topographic map of about 15 square miles around the dam site was needed, to embrace the town site, camp site, and the approaches to the dam site, such as railroad, highway, and tramway locations. The specifications required a scale of 1 in. = 400 ft. and a contour interval of 5 ft. Finally, a controlled aerial mosaic of about 50 square miles around the dam site, to a scale of 1 in. = 400 ft., was needed.

The award for supplying the lower river mosaic was made to Fairchild Aerial Surveys; that for the detailed survey of the dam site to the Aerotopograph Corporation of America; and that for the map and mosaic of the construction area adjacent to the dam, to Brock and Weymouth, Inc.

The steepness of the walls and the accompanying difficulty, if not impossibility, of climbing the cliffs and moving about in the canyon made it impracticable to map Black Canyon accurately by means of the usual ground survey methods, on the scale and with the contour interval specified. The use of vertical aerial photography would not reveal the hidden areas under the overhanging cliffs and in the deep caves. The bureau, therefore, very properly restricted contractors to the use of photography from ground stations by means of a photo-theodolite.

Control by Triangulation and Leveling

There was no practicable base line site for the control triangulation net near the canyon rims, so a site was selected in Construction Camp Basin. Here, as may be seen from Fig. 1, it was only possible to secure a base about 735 ft. long, but as the longest side in any of the main scheme figures was only about 2,000 ft., this was found to be ample. The base was measured with a 300-ft. steel tape which was tested by the Bureau of Standards before and after the survey was made. Except that an invar tape was not used, the work was conducted in the usual manner, with all necessary preparation and care. The base was measured eight times, four at about 8 p.m. with a temperature of 98 deg. fahr.,

Looking up Black Canyon Toward the Dam Site from the Nevada Side

and four at 5 a.m. with a temperature of about 90 deg. fahr. The necessary reductions for temperature, tension, and slope were made, and the probable error in measurement was computed to be about one part in 150,000.

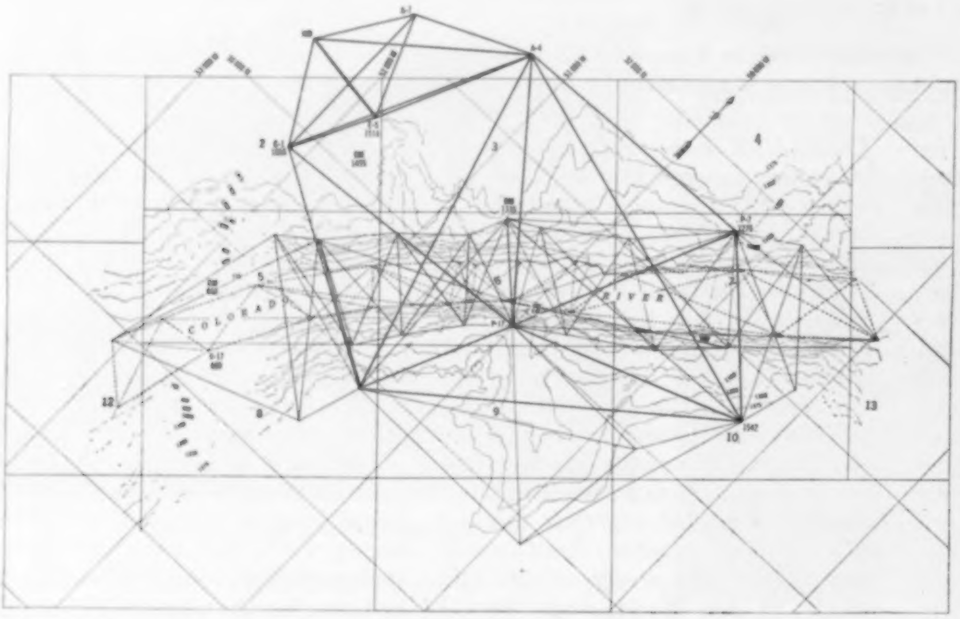


FIG. 1. THE TRIANGULATION NET AND MAP SHEET INDEX

THIRD-ORDER ACCURACY REQUIRED

Because of the extremely rough terrain and the difficulty of climbing cliffs with heavy instruments, the triangulation was executed with a small 4-in. theodolite reading only to the nearest minute. By taking six readings direct and reversed, the probable error in observed direction was kept very low; later computations indicated that this was not over 4 sec. in the main scheme, within the third-order accuracy required by the specifications.

Eleven stations were occupied in the main scheme; in addition 15 supplemental stations were occupied on the canyon rim, and 19 at the bottom along the water's edge. Also, 17 signaled stations and a large number of unmarked points were located by intersection. The location of 62 flagged stations is a large number in an area of less than one square mile.

With the usual precautions for third-order leveling, a spirit level line was run from the datum bench mark at the water's edge, about 2,000 ft. below the dam site, up Water Trail Canyon, to the rim above. Spirit level bench marks were established at four of the main scheme triangulation stations, and elevations of the other stations were determined by reciprocal vertical angle readings by means of the theodolite.

Checking against the independent work of Brock and Weymouth, coordinates of a common point farthest removed from the origin agreed within 0.25 ft. Duplicate leveling agreed within 0.02 ft.

TOPOGRAPHY BY PHOTO-THEODOLITE

While the triangulation was being executed, the photographic work was carried on by the second party. This part of the work was extremely difficult. The photo-theodolite in its case weighs about 75 lb.; the two tripods and range-rod case are both heavy and bulky and the plate magazine case had to be handled with great care. This equipment, which can usually be transported by one good pack animal, required four men to carry it over the rough terrain at Hoover Dam. Heavy lights and shadows made it necessary to take photographs away from the sun, and when the cliffs were well illuminated. Therefore, it was possible to photograph the west wall only in the morning and vice versa. Due to the extreme heat, the photographer was forced to keep the plates in the shade and to protect the camera from the sun as much as possible while at work.

Any point on the terrain can be located in its horizontal and vertical positions by computing or plotting the intersection of two lines of sight from two base-end stations. Therefore, the photographs were taken from each end of a measured base, so as to form pairs covering the same terrain, with the optical axis of the camera parallel at the two stations. Each of these pairs of photographs, when properly adjusted in a stereoscope, forms a stereoscopic model in which all of the features are represented in true perspective and in three dimensions. Instead of sighting actual points with a transit or a plane table, the images of these points as they appear in the stereoscopic model are sighted and intersected by means of a combination viewing, measuring, and plotting stereoscope known as the aerocartograph, described later.

The accuracy with which these points can be located stereoscopically depends on the accuracy with which the angles of intersection can be reconstructed in the plotting instrument. Experience has shown that the probable error of reconstructing an angle of intersection by plotting from terrestrial photographs in the aerocartograph is about 10 sec. of arc. The accuracy of plotting decreases with the square of the distance from the base ($B = 0.00005\ D^2$). In order to guarantee the required accuracy, bases are usually selected with lengths about 20 per cent longer than the computed requirement; for a depth of field of 1,000 ft., a base about 60 ft. long was used. These bases were selected with the greatest care so that the field would be thoroughly covered and there would be no hidden areas.

The photo-theodolite is a camera fitted with accurately graduated horizontal and vertical circles and with a device for sighting points, so that the horizontal and vertical angles can be measured accurately. Some types have a theodolite mounted on top of the camera, but the particular type used on the Hoover Dam survey, known as the Hugershoff Universal Photo-theodolite,

is essentially a camera from which the plateholder can be removed and an eyepiece substituted so as to form a theodolite, the camera lens being used as the objective lens of the theodolite and the line of collimation being identical with the optical axis of the camera.

Both horizontal and vertical circles are built in the camera mount and permit micrometer readings to the nearest tenth of a minute. The camera is of the fixed focus type, adapted for use with glass plates, 13 by 18 cm., or about 5 by 7 in. In exposing a plate, it is pressed against the measuring frame, thus securing its proper position in the focal plane of the lens. Register marks, which are photographically recorded on the plate at the instant of exposure, serve to reconstruct in the aerocartograph the position of each individual plate in the focal plane with respect to the camera axis. The photographic field can be examined by means of a ground glass plate or a collapsible finder frame. The camera is reversible on its horizontal axis.

TELESCOPE EYEPIECE SUBSTITUTED FOR PLATEHOLDER

When the camera is to be used as a telescope, a special eyepiece is attached to the measuring frame by means of four clamps, and the shutter is opened so that the lens serves as the object glass. The power of magnification of this combination is about 15.

Two tripods are used, each being carefully leveled and centered over one of the base end stations. The photo-theodolite is placed on one tripod. On the other, the range rod is leveled in a horizontal position exactly perpendicular to the base, by attaching a small telescope and sighting on the center of the camera lens or the camera plumb bob line at the other base station. The range rod is in three sections, each 1 m. long, suitable for use on different length bases. It is graduated in decimeters for telemetric observations.

The horizontal slow-motion tangent screw of the instrument is designed as a micrometer screw, the circumference of which is divided into 100 parts. The cross hair of the instrument is set on the index mark at one end of the range rod, and, by turning the micrometer tangent screw, the line of collimation is turned on the vertical axis of the instrument until the cross hair cuts the index mark at the other end of the rod. This operation is repeated several times in both directions, that is, from left to right and vice versa. Each reading on the micrometer screw is recorded and the mean of the readings is used in the computation of the base length. The length of the base is computed by the formula,

$$B = \frac{L}{N} \times C$$

in which

B = the length of the base

L = the length of the range rod

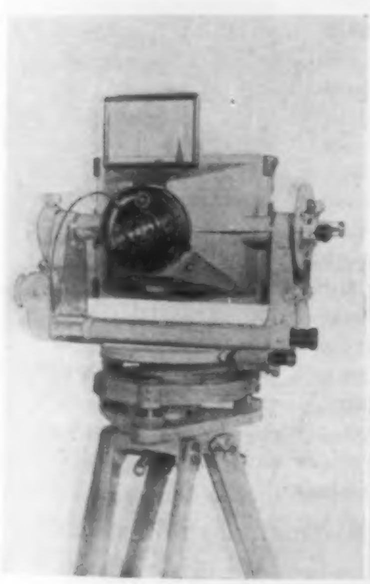
N = the number of turns of the micrometer screw

C = a constant, derived from the pitch of the tangent screw and its offset from the vertical axis of the instrument, the value of which is made approximately 100.

Since the intercepts are measured as horizontal angles, the computed base length is in the horizontal plane. By this means, the length is determined with high precision and with more facility than by means of a tape. The difference of elevation between the two stations is derived from vertical-angle readings on the target index and the computed horizontal length of the base. A typical example of the measurement of base length and difference of elevation is given in the specimen page of field notes, Fig. 2.

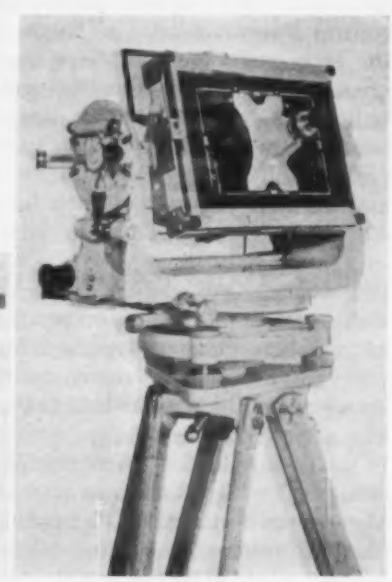
Theoretically, there is no restriction as to the difference in elevation of the two base end stations, but if the base is to be measured by the methods just described, the inclination should not exceed 30 deg. If other means of measurement are provided, the inclination can exceed this amount and, if desired, the base can be vertical.

The range rod is then removed from its support on the head of the tripod and a target substituted, or else an index mark on the range rod mount is used for a target. The horizontal circle on the photo-theodolite is set exactly at 0 or 180 deg., depending on whether it is on the right or left-hand station. With the horizontal circle clamped at that reading, the



Front View

Range Rod and Tripod



Rear View

THE UNIVERSAL PHOTO-THEODOLITE AND ROD

camera is rotated on its vertical axis so that the cross wire in the theodolite attachment is centered exactly on the target index. This orients the photo-theodolite

Project .... Base # 26 Page # 52

Description of Location 150 ft South West of P.L. opposite P20

Operator H. Gruner Date Aug 18 30 Hour of Exposure 2:00 PM

Optical Measurement of Base Length						
Length of Range Rod	Readings On: Left Mark	Readings On: Right Mark	Difference	Average	Instrument Constant	Horizontal Base Length
100 cm	8.382	11.601	3.219	3.216	100.520	31.257 m
	.391	.604	.212			
	.384	600	216			
	.391	606	215			
	.384	601	217			
			30			

Left Station: Photo	Line of Sight	Horizontal Circle	Vertical Circle	Remarks	Right Station: Photo	Line of Sight	Horizontal Circle	Vertical Circle	Remarks
	R. Sta.	180° 00'	346°00'			L. Sta.	0° 00'	165°37'	
Stereo Control	P20	58°52.0'	5°17.5'		Stereo Control	P20	53°40.4'	173°35.0'	
	P22	81°57.1'	4°48.1'			P22	76°08.7'	173°18.0'	
	P24	99°03.5'	5°58.4'			P24	93°41.6'	172°05.3'	
	P27	109°36.0'	2°36.5'			P27	104°15.0'	176°51.2'	
157	Camera Axis	60° 00'	5° 00'		164	Camera Axis	60° 00'	175° 00'	
158		90° 00'	5° 00'		163		90° 00'	175° 00'	
159		120° 00'	5° 00'		166		120° 00'	175° 00'	
160		60° 00'	25° 00'		165		60° 00'	155° 00'	
161		90° 00'	25° 00'		168		90° 00'	155° 00'	
162		120° 00'	25° 00'		167		120° 00'	155° 00'	
	R. Sta.	180° 00.4'		Check		L. Sta.	0° 00.3'		Check
Base Location				Telescope Inverted					
Height of Instr.	148 cm = 4.9 ft				Height of Instr.	140 cm			

Recorder: F. Clancy

FIG. 2. A SPECIMEN PAGE OF PHOTO-THEODOLITE FIELD NOTES

and permits the measurement of horizontal angles at the photo-theodolite station between the base line and any other point.

After the alidade of the instrument is unclamped, horizontal and vertical angles are read to all visible control stations needed to locate the camera station by the three-point method. Horizontal and vertical angles are also read to all other triangulation points that can be identified in the photographs to be taken from that station. In the Hoover Dam survey, practically all the photographic bases were near triangulation stations and at least one end of each base was located and its elevation determined by the triangulator.

TAKING THE ACTUAL PHOTOGRAPHS

As soon as the photo-control work is completed, a plate magazine is substituted for the sighting device, and the observer is ready to take the photographs. In all cases, the preparation takes much more time than the actual photographing.

In the simple case where one photograph only is taken from each end of the base, normal to the base and level, the camera is turned on its upper motion and clamped at the horizontal circle reading of 90 deg. and at the vertical circle reading of 0 deg., which indicates its level position. In the most complicated case, nine photographs, in three sets, are taken from each end of the base—one set elevated, one level, and one depressed, with points in each set to the left, to the right, and normal to base.

At each setting a plate is exposed, using, of course, the proper time, stop, and filter, depending on conditions of light and subject. Each plate magazine contains two glass plates, 13 by 18 cm. The magazine case holds 12 magazines and the camera case has carriers for two more, so that the standard equipment provides 14 magazines, or 28 plates. This is usually sufficient for a single day's work and the magazines can be reloaded at night, even in camp, by means of a dark-room tent.

As soon as the work at one end of the base is finished, the camera and target are interchanged, the operation being performed with great care so that the position of the tripods is not disturbed. At the second base station it is usually not necessary to check the length of the base, but all the other operations are repeated. Complete notes are kept for each base station and exposure, so that the proper computations can be made later. The horizontal and vertical readings, with respect to the direction of the base and the instrument's horizon, become the characteristics of each individual photograph and are called the orientation data of the camera.

PHOTOGRAPHIC FIELDS OVERLAP

A stereoscopic pair of photographs covers a V-shaped section of the landscape with an angular width of about 40 deg. If the dimensions of the area to be mapped demand a larger photographic field, and if the natural obstructions in the foreground do not prevent, additional photographs are taken from each station so that the field of each joins that of the adjacent photograph, either laterally or vertically, with a sufficient amount of overlap to avoid gaps between the several stereoscopic models that will be formed in the plotting instrument.

After all of the bases have been occupied, the field work is completed. It is wise, of course, to develop the plates before leaving the vicinity. In the case of the Hoover Dam survey, the photographer developed all the plates in Las Vegas, frequently working all day in the field and half the following night in the laboratory. He also made preliminary prints from each negative for the use of the triangulator in selecting and locating critical points that could be identified on the ground.

TRIANGULATION STATION P-2

An attempt was made to locate at least two, and preferably three points on each photograph, but the triangulator sometimes failed to identify points from the second or third stations. In every case of failure, however, the photographer was able to fall back on his photo-theodolite observations and secure enough control to hold each stereoscopic pair.

MEASURING AND PLOTTING THE TOPOGRAPHY

It is difficult to comprehend the actual operations of plotting the map data by stereoscopic methods without actually seeing and studying the measuring and plotting

instrument, called the aerocartograph, which permits the viewing, measuring, and plotting of stereoscopic photographs, either aerial or ground, all in one operation. This brief explanation is limited to its use for photographs taken from ground stations.

As an instrument, the aerocartograph may be considered in three parts—the optical, measuring, and drawing systems. The optical system consists of a binocular telescope which enables the operator sitting in front of the instrument to observe at the same time two corresponding images of the same point just as though he observed the actual point on the ground, once with a telescope from the camera station at one end of the base and again with the telescope at the other end.

Two corresponding plates, one taken at each end of the base, are placed in the plateholders and adjusted so as to form a perfect stereoscopic model when viewed through the eyepieces of the binocular telescope. By this is meant a single plastic model giving the same impression of depth as is perceptible to human eyes in viewing nearby features, except that the impression is magnified by the increased length of the base.

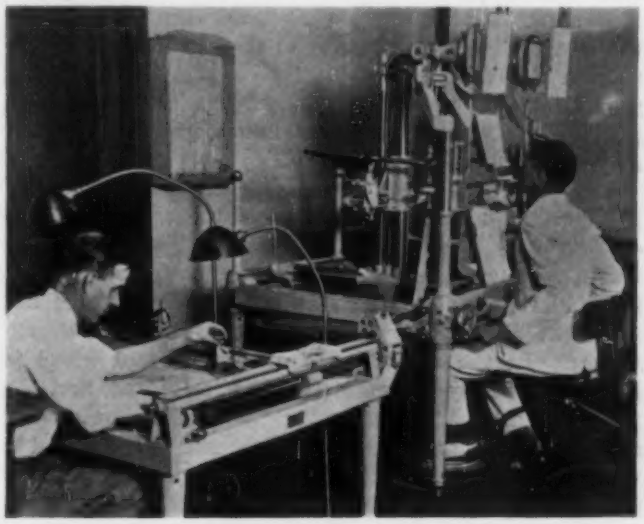
FUNCTION OF THE FLOATING MARK

In the focal plane of each viewing telescope, there is an index mark, corresponding to the cross hairs in a transit. In proper stereoscopic vision, these two marks are fused into one image or pointer, usually called a "floating mark" because it appears to float over the model. In the back of each plateholder is a lens which is of the same focal length and has the same optical properties as the lens in the camera. Light is thrown through the transparent plates in the plateholders and the image rays from each pass through a series of lenses and prisms to the eyepieces. Focusing devices are provided so that the images can be brought to the same scale, can be enlarged or reduced, and the eyepieces can be adjusted to fit the observer's eyes.

The line of collimation of each observing telescope in the aerocartograph is resolved into a horizontal and a vertical component which can be read in angular units. However, the operator is not concerned with the measurement of single directions in space, but with the intersection of two lines of sight which determine the location of a point in its three coordinates. The binocular measurements permit the location of this intersection in the three-dimensional coordinate system, the horizontal position being recorded either graphically or on the two horizontal coordinate scales, and the elevation being recorded on the vertical coordinate scale.

Photographer at Work

Just as the transit can be directed toward any point in the field of view, so can the fused floating mark in the binocular telescope be directed toward the stereoscopic image of any point in the optical model. In order to comprehend the function of the fused pointer or floating mark, it is necessary to have a clear understanding of the principles of perspective and parallax. This floating mark provides a reference mark by means of which the varying parallax caused by changes in the depth of the field of view can be made apparent. By moving one of the plates toward or away from the other, parallel to the base, the parallax existing between the mark and the image of the ground may be changed and the mark will appear to be farther away or closer to the image of the ground. By eliminating the parallax, the mark will appear to touch the surface of the ground, which is the condition the stereoscopic operator must attain.



Coordinatograph (Left), Aerocartograph (Right)

Apparently, the floating mark can be moved in the three dimensions of space by turning two hand wheels and a foot plate, the left wheel moving the mark in the X coordinate to the right or left, the right wheel moving it in the Y coordinate toward or away from the observer and the foot wheel moving it in the Z coordinate up or down over the optical model. This is just the reverse of what actually happens, but it is easier to explain the apparent movement in this way, just as one explains the relative positions of the earth and sun by speaking of the apparent rotation of the sun around the earth. In fact, the index marks are fixed in the two telescopes and the telescopes also are stationary. What actually happens is that the plateholders and all the connecting bars move when the wheels are turned.

DRAWING A HORIZONTAL PROJECTION

The drawing mechanism consists of a three-dimensional coordinate system functioning with the optical and measuring systems so as to draw a horizontal projection of the stereoscopic images to the map scale desired. All the available control points, including the photo-base stations, are plotted on the map sheet, prepared on the proper projection and to the proper scale. This sheet is placed on the drawing board in the base of the instrument, or preferably on a separate drawing table known as the coordinatograph, and properly oriented with relation to the direction of the photographic base. The stereoscopic model is then adjusted to its horizontal projection and to the scale of the map by proper settings on the plateholders and scale bars.

When this has been satisfactorily accomplished, the floating mark can be placed on the image of each control point in the model. The pencil in the plotting device will then register the location of each point exactly as previously plotted on the map sheet, and the Z coordinate scale will indicate the correct elevation of each point. It is apparent that the floating mark can be placed on the image of any other point in the stereoscopic model so that it seems to rest exactly on the surface of the ground at that point. The pencil will plot its correct position on the map, and the elevation scale will indicate its correct elevation.

The operation, then, is to trace lines and not simply plot points and interpolate between them. In the case of a road, trail, or stream, the image of the feature is traced on the model by moving the floating mark over it, and keeping the mark resting on the surface of the model at all times by means of the three coordinate wheels. In the case of a contour, the foot wheel is locked at the proper setting for that elevation, and the floating mark is "forced" over the model, but always apparently touching its surface, by means of the X and Y wheels alone. Inasmuch as the Z coordinate wheel is set for the proper elevation readings and is not moved, the line traced by the pencil must be the proper contour.

When the drawing of one photo-pair has been completed, the adjacent and slightly overlapping pair is inserted in the plateholders, and the new model is adjusted to the map sheet. The process is then continued until the map is completed.

STEREOSCOPIC DRAWINGS TRANSFERRED TO FINAL SHEETS

Of course, the entire map project may cover many sheets—12 in the case of the Hoover Dam project. Moreover, the preliminary drawings on the sheets of the stereoscope seldom fit the size and shape of the final map sheets. Then again, the stereoscopic drawings need some retouching and sometimes some adjustment. In the Hoover Dam project, each stereoscopic drawing usually fell on two if not three or four final sheets. It became necessary, therefore, to cut up the original drawings and to adjust them in proper position on metal-mounted sheets of final sheet size.

Inasmuch as the specifications called for the delivery of original drawings, and a "mosaic" made up of pieces of drawing paper pasted together would not be acceptable, it was found necessary to copy and ink these assembled sheets on other metal-mounted sheets. The topography was so intricate that the contours could not be traced and transferred, so photo-lithography offered the only suitable method. This involved preliminary inking of the contours in order to secure clear photo-lithographic impressions. This preliminary inking caused delay and additional expense which is being avoided in other projects by etching the stereoscopic drawings on coated glass plates, but in the case of the Hoover Dam survey the preliminary inking, although somewhat crudely done, afforded a means of delivering advance sheets considerably sooner than the final sheets could be made available.

The photo-lithographic impressions were printed in non-photographic blue on drawing paper sheets mounted on metal. These became the final original drawings and were inked carefully by skilled topographic engineers who were also expert draftsmen. Considering the very large scale on which the maps were drawn, the necessity for accuracy of contour delineation, the difficult terrain, and the unusual weather conditions, it is of interest to note that only 131 days in all were required to complete the map construction. It is hardly conceivable that satisfactory maps could have been made in any shorter time.

The illustrations here shown include a reproduction of the index sheet, Fig. 1, on which the horizontal control scheme is plotted, and a reproduction of a part of Sheet 6, Fig. 3, on which the location of the dam is indicated.

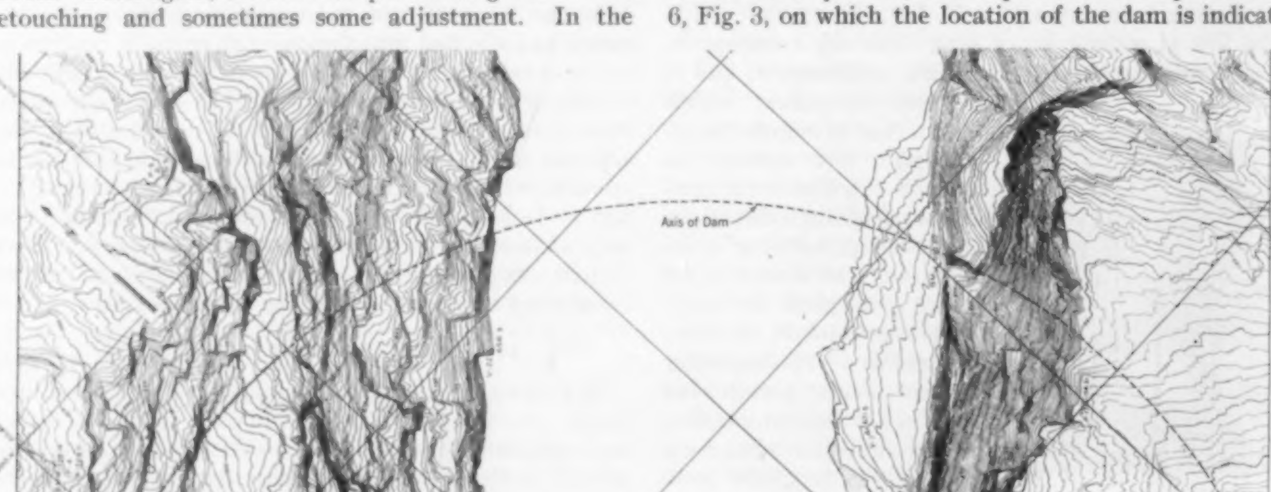


FIG. 3. A PORTION OF THE MAP SHEET ON WHICH HOOVER DAM IS TO BE LOCATED

Logic in Engineering Diagnosis

A Critical Analysis of the Engineer's Mental Processes

By THADDEUS MERRIMAN

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IN a characteristically vigorous way, Mr. Merriman here opens a field for thought that has received all too little attention. Are engineers the slaves of formulas? Do they accept the veracity and accuracy of the printed word unquestioned? Is the education of the engineering student so systematized and standardized that his horizon is limited and his ability to think for himself circumscribed? Mr. Merriman points out the danger of accepting blindly the conclusions of scientific investigations when logically the truth of the assumptions made in each step of the analysis which led up to them should be inquired into. The paper forming the basis of this article was presented at the Summer Session of the Society for the Promotion of Engineering Education at Yale University, on July 22, 1930.

LOGIC is the science of correct thinking; it is the art of reasoning. Logic is the science of connecting and contrasting inferences, as much as it is the art of deductive reasoning. Logic is the science of concepts as means to an end, yet no pure concept is valid until it has been proven by the results of observation. A proven concept is demonstrated truth. Judgment is the result of reasoning from proven concepts. The value of a judgment is in proportion to the experience of its pronouncer. Thus is logic seen to be both a science and an art. Science connotes orderly observation of fact, while art is the practical and skillful application of demonstrated truth, of pure concept, and of transcendent inference.

From Aristotle down through Kant to Herbert Spencer, the study of logic has forwarded all processes of thought and been the means of great advancement in human understanding. In the world of every-day life, logic makes its presence felt at all times and in all places. Logic makes its closest contact with human affairs when it is considered as a tool for every-day use rather than as a science to be expounded.

That which is entirely logical to one man may be wholly illogical to another, not because the logic of either is in error, but because the logic of neither has been completely and correctly expressed. Agreement on any particular set of facts is possible only when they are impartially viewed through the microscope of reason.

STUDENTS SHOULD DEVELOP INDEPENDENT THINKING

Now what is the relation between logic and education? The boy goes to college determined to acquire his fill of knowledge. By nature he is precocious and his mind is full of questions. He wants to know the why of this and the why for that. But what happens to him? He is given various texts which he must study and upon the contents of which he must recite. Those books contain the gospel and that, whether he will or not, he must learn.

In this process, the sharp edge of his natural bent for truth becomes dulled and, after four years, much of his inborn ability to apply his own logic has disappeared. He becomes content to accept the logic which others have written as well as that which his teachers expound from the rostrum of the lecture room. Even as the boy's pencil flies back and forth across his notebook, the development of his own intuitive logic is suppressed and retarded. So the reasoning of others is impressed upon his mind and neither he nor his teachers are aware either of the process or its results. Education thus tends toward uniformity of thought, and uniformity spells average.

This is the tendency of the day in the world of trade as surely as in the world of education. In both fields, however, the need for betterment is making itself evident. The research laboratory in commerce and the post-graduate course in the university are both symptoms of that tendency. The post-graduate course, however, starts after the harm has been done and seeks to widen the horizon of the boy after it has been circumscribed by four years of repressive instruction. This course would be best did it begin in the freshman year!

Because of the average and formal basis of his education, the technician generally looks with reverence upon the formulas of his trade. He comes to think in terms of coefficients and to believe that the difficulty of the application of these formulas lies simply in his own inability to properly select the constants. Seldom does he consider that the formulas are merely devices for approximating the effects of physical forces and that, at very best, they merely tell a part of the truth. Few, if any, of the formulas now in existence actually express ultimate truth because none is wholly logical.

The technical man is not the only victim of a narrow horizon which results from his education. This disability is widespread and extends into all the professions. Early in his course, the law student is taught the phrase, *currere solebat*, as the statement of a principle of the common law, that is, the riparian doctrine. Water must flow as was its wont. Thereafter, that student, taking his place in society, finds the abstract theory represented by this phrase so firmly founded in his thought that it stands for him as something which is final and absolutely determinate. For this belief he can give no logical reason nor does he appreciate that this law is merely the statement of an ancient principle which, while once logical, is as rapidly being outgrown as has been that of absolute right in property, under which a man could do with his land as we would. From the zenith of the earth's center and within the limits of his property the owner was held supreme. But along came "police power" with its zoning laws to limit the quality of his ownership. And

now, without sanction of any law, the airplane trespasses over his lands at will. From the absolute, life constantly tends toward moderation. The drift is always toward viewpoints which are more moderate, more reasonable, and consequently more logical.

But where does logic stand in relation to the technical practice of engineering? This is a matter which comes close to home, although what has already been said is almost as near. Here it may be ventured upon only because it is instructive, now and again, for us to glance back over our work, to look around on what others have done, and then, by comparison, seek to measure and to evaluate, first, the quality of our effort, and, second, the quality of the science and the logic that we employ. Introspective analysis is a most wholesome pastime. It is good for the soul as well as for the heart and the mind. It teaches honesty toward one's self and often forcefully brings into the open the logic of a problem or of a situation.

So may it be said that the engineer, who, of all men, should be the most logical, seldom uses logic himself. In his contacts with his fellow men he is prone to be "technical." Rather than express himself in common parlance, he uses the vernacular of his profession. Naturally, therefore, he is often looked upon as one who probably knows his job, but, beyond that—well, something is lacking.

LOGIC IN EXPERT TESTIMONY

This very subject is frequently discussed under such headings as "The Place of the Engineer," "The Engineer's Status," and others of like import. These dissertations, more often than not, fall short in their applications of logic. They express a yearning and look only to abstract justice as a hope of remedy. The arguments advanced may all be entirely correct, yet each falls short in so far as it overlooks the fundamental causes which are to be found only in the logic of the situation. Nearly all of the remedies presented may be classed as nothing more than palliatives. A better diagnosis would indicate the efficiency of a super-dose of logic. The administration of this tonic, if it is to be most effective, should, however, be begun not later than the first month of the future engineer's freshman year.

In a number of cases the Supreme Court of the United States has said, in effect:

"Here we have as many eminent and qualified experts on the one side as on the other. They differ flatly as to all technical matters. These things the Court cannot understand and so it must look for some simple and outstanding fact on which its decision may safely be based."

Is this a fair sample of the result of lack of logic in engineering practice? It is, at all events, a simple statement of what frequently happens and the wonder of it all is why the engineer himself is not the first to seek for the "outstanding fact." Juries are just as human as judges. Seldom does the engineer differentiate between them and seek to adapt his logic to the particular jury before which it is his lot to appear. Even if it be granted that the lawyer, by virtue of his profession, is a partisan in the cause he represents, it also appears that the inflexibility of the engineer's education tends to impel him to extremes to which even his own counsel might not go, did he but know the facts. The engineer in the rôle of a partisan cannot be a success. Logic and expediency will not mix.

HUMANIST VERSUS SCIENTIST

About five years ago the convention of an American technical organization was held in one of our great cities. It was a most interesting meeting, not because of the technical papers, which have long since been forgotten, but because of what happened at the annual dinner. At that function an eminent professor of English, and an able student of logic and human relationships, was the first speaker. He eloquently stressed the value of imagination in life and emphasized the importance of ambition, of effort, and of concentration. He pointed out that at the bottom of these qualities lies the dream. All of them, he said, are founded upon the imaginative dream—on the dream of success, on the dream of greater understanding. The audience, however, did not respond to the appeal which was made because it was largely composed of practical men who dreamed only of steam shovels, of concrete yardages, of cement in thousands of barrels, and of steel in millions of pounds.

Following the professor of English came one of the country's most famous astronomers. He portrayed the advancement and the wonders of his science. He sought to credit the progress of astronomy to the standardizing efforts of the engineer and many times referred to his colleague, the professor of English, as a dreamer whose art could not avail the science of which he and his engineer listeners were the masters. Naturally, the audience was with him and it was easy to sense that the astronomer was merely carrying on an informal psychological discussion on which he and the humanist had long taken opposite sides.

So great an impression did the contrast make on me that I communicated with the humanist to congratulate him on his presentation. As a student of the mind and of the heart he had given voice to the human side of the infinite, which stretches out in directions that the science of the astronomer is unable to measure or even to visualize.

The astronomer, good naturedly but, I think, a little inappropriately for his audience, took issue with the philosopher. He held that to standardized science should go the credit for the development of the telescope and all its host of marvelous accessories. Had the professor but had the opportunity of replying, he would undoubtedly have said that no single thing in all the equipment of the astronomer is standard but that, in fact, each and every part is special and stands as the very best of both its type and kind. He would have gone on and said that every part was the result of the God-given ability of the specialist who, after years of toil and perseverance, profiting alike by failure and by success, finally came to see at least the beginning of the realization of a dream.

The astronomer, standing reverently in the presence of an infinity which his mind cannot encompass, dreams the dream of greater visibility. The philosopher, viewing the things about him as they are, looks to more comprehensive understanding through the telescope of history, and dreams the dream of human progress.

In the eyepiece of his reflector the scientist sees in dim perspective the myriad dreams of humankind, which, unrecognized by him, form the background of his visible field. The philosopher counsels all men with him to dream his dream. The scientist prone would dream his dream alone, and if by chance he does not dream he counts it error grave to dream at all.

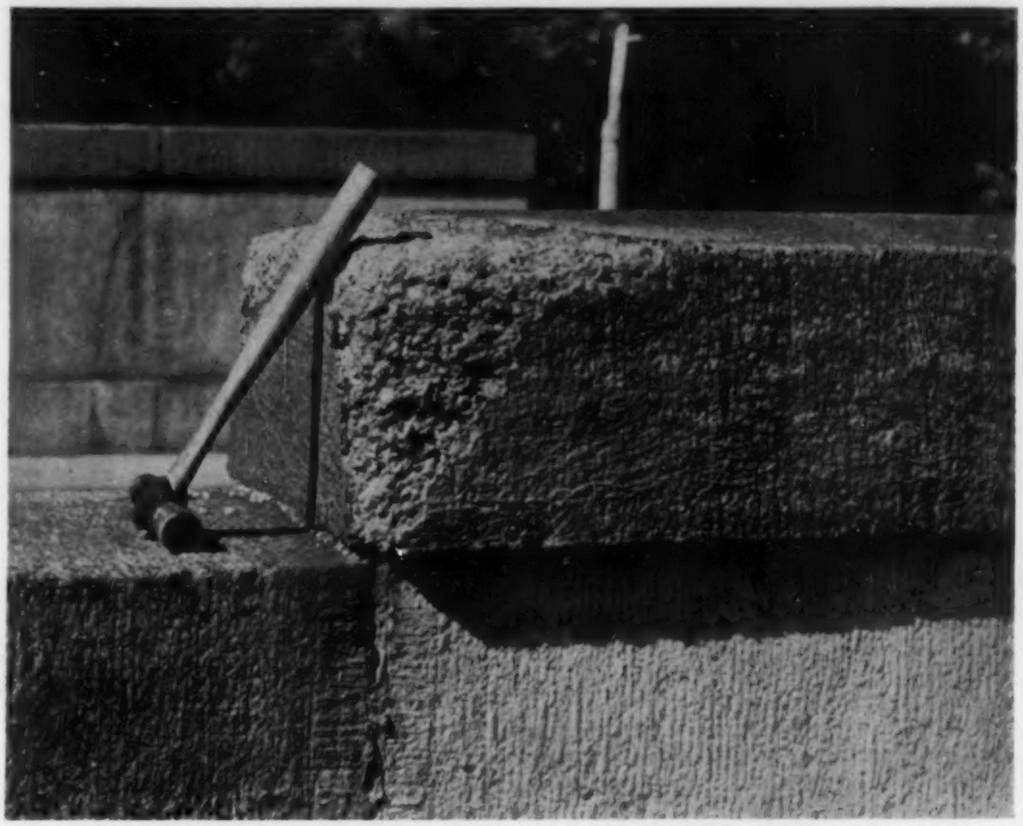
So is logic influenced, directed, and encompassed by the point of view! So does the engineer, because of his training, often fall short of the goal which from every angle of logic should be his.

ERRORS AND OMISSIONS EXCEPTED

Mathematics is the only field in which logic may be said to attain absolute precision but a theorem in pure mathematics differs greatly from the application of mathematics to the solution of engineering problems. The theorem may be proven absolutely, while the mathematical analysis of a structure like a dam is not at all susceptible of complete demonstration. No such analysis can possibly be as valid as the assumptions on which it is based, yet the engineer tends to accept the final equation and is prone to use it in the solution of his problem. Logically, every such equation should be stated as follows: "This equation is only correct if each and every one of the assumptions made in the process of its derivation is not in error." Instead of writing Q. E. D. after an equation, logic requires that E. and O. E. should here be used.

The mathematics used in the process of deriving an equation may be entirely sound, yet the result, while mathematically logical, may be seriously wrong. Mathematical analysis is a process based on logic. Once an assumption has been made, the mathematics proceeds until the next assumption becomes necessary. The process is not unlike an adding machine. No matter what key is depressed the machine will produce a correct answer. In the case of the machine, the value of the product depends on the accuracy of the operator, while in the case of the mathematical process the result is dependent on the validity of the assumptions which have been fed into it step by step. The validity of the assumptions is, in turn, a direct function of the skill, the experience, and the soundness of the analyst's judgment. Logic clearly shows that the mere ability to prepare a mathematical analysis is not a guarantee of the correctness of the results it produces.

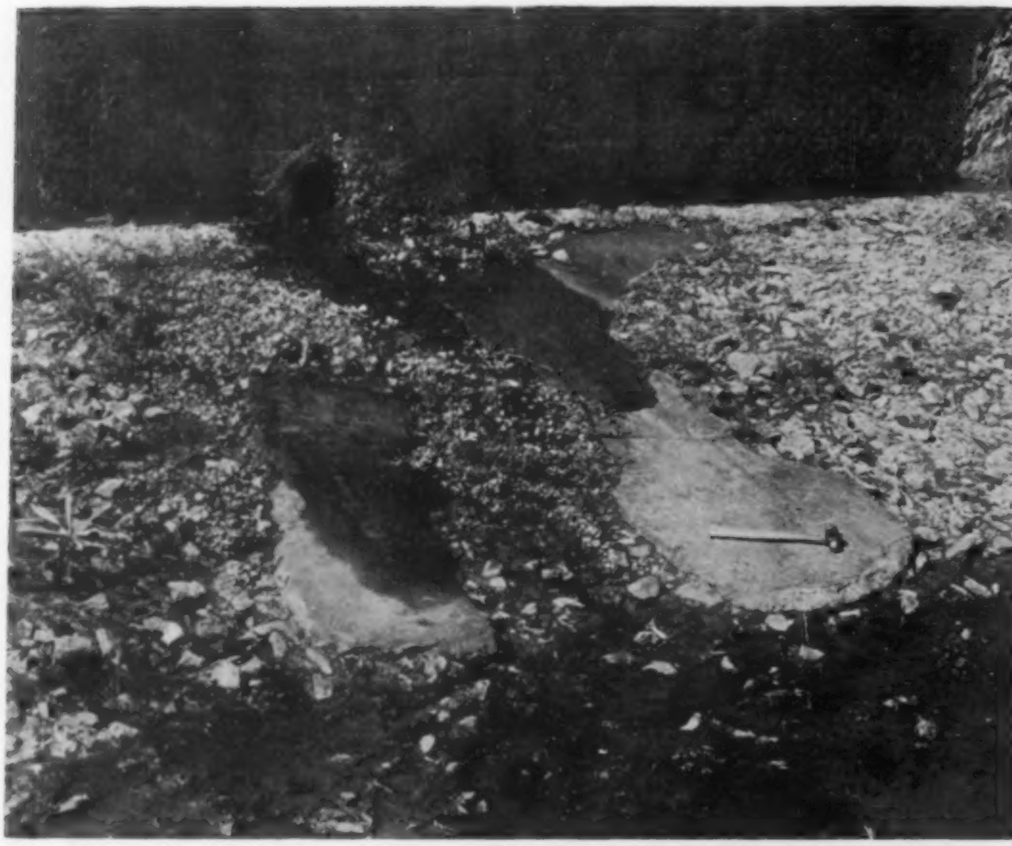
Here the difficulty lies in the emphasis which is placed on the value of anything that is called a mathematical analysis. Let a problem be analyzed mathematically and the solution becomes sacrosanct, as though the symbols of integration and differentiation were palliatives to correct the errors of the assumptions on which the entire process is based. Mathematics is the science of form and of quantity, while mathematical reasoning is merely the logical application of the results of observations on form and quantity, than which, of course, the entire process can be no better. The master of logic is ever awake to his own limitations as well as to those of the reasoning he employs. The tyro sleeps the sleep of satisfaction and self-confidence.



DISINTEGRATION OF A CONCRETE BALUSTRADE

About 70 per cent of the blocks in this balustrade have seriously deteriorated. All of them came from the same plant. Those which have disintegrated seemed dead and did not "ring" as did other blocks from the same plant, made with the same aggregate but with different cement. The logic of the situation indicates that all cement does not have the same concrete-making qualities.

To decry either mathematics or mathematical analysis is farthest from my thought. Mathematics is one of the most useful of the scientific tools that logic has developed. My purpose is simply to point out that engineers as a class are prone to accept anything which resembles a formula without inquiry as to the logic that led to its creation. Percival Lowell, in the preface of his book on *Mars and Its Canals,* pictured the importance of understanding analysis by pointing out that "Formulae are the anaesthetics of thought, not its stimulants." "Did one," he said, "but know the uttermost of a subject



DISINTEGRATED CONCRETE IN A CHANNEL FLOOR

This deterioration began shortly after the concrete was placed and was remedied by patching. The disintegration continued, but the patches endured. About 100 ft. of the floor of this channel have deteriorated as shown. The remainder is in fair condition. It seems logical that the quality of the cement was a factor in the result. The cement came from a plant, the outstanding characteristic of which was the variability of its product.

he could make it singularly clear." This is a wonderfully expressive statement that truth to be true must be logical as well as correct.

LOGIC APPLIED TO USE OF CEMENT

Portland cement concrete is a material used in nearly every field of engineering and yet there is more uncertainty regarding it in the minds of its users than there is as to many other materials. This situation seems to be the rather logical result of the lack of logic with which this material has been studied. In the great field of engineering materials, hardly one has had more effort expended on it with so few definite results. Millions of specimen cylinders and briquettes have been tested to mechanical destruction. Yet the ultimate goal still seems to be far off. But how may the absence of logic be said to affect this situation?

During the past 15 years various slogans have had their day. Among these was the "fineness modulus," a device for regulating the strength of concrete by modifying the sizes and quantities of the aggregates so as always to produce a maximum of strength with a minimum of cement. Logic, either with or without the admixture of a little business instinct, would never have advanced so naive a proposition. Then came the "surface area" method while concrete was being advertised for "permanence;" then the "slump test;" and now we are in the era of the "flow table" and "the water-cement ratio," which enables everybody to "design" his concrete. Always has the millenium been at hand. Never has the searchlight of logic turned its rays into the darkness. The picture has always been one of a slogan set up as a totem pole so that the engineers might gather around it just as the brokers on the stock exchange rally around their "posts." No slogan has ever been the outcome of logic.

The best stone, sand, and water in all the world will never make concrete unless cement is used in addition. Logically it ought to follow, therefore, that the quality of a concrete, above all else, is an important function of the quality of the cement. Why is it that there has been so little discussion of a proposition so seemingly axiomatic? The answer here seems to lie in the general though unfounded and illogical belief that portland cement is a standard material which varies not at all in either its quality or its characteristics and that, therefore, the only possible variables in concrete are those which are obvious even to the freshman.

How, now, does the situation just presented fit in with the text of this discussion? Very aptly, it may be said, for it shows that the engineer in his attitude toward concrete has neither subjected it to rational analysis nor viewed it through the microscope of logic. Who has inquired as to the logic of the "water-cement ratio?" Let us do so now for a brief moment.

No cement will set without water. Therefore, water is necessary. But how much? Well, enough to make a workable mix. But how much is that? That depends on where the concrete is to be placed. If the spaces to be filled are small, then more water may be used than if they are large, but always as little as possible. But why is this so? Because experiments have shown that the smaller the quantity of water the stronger the concrete will be. So runs the argument to a seemingly incontrovertible conclusion, yet it fails entirely to answer the question, "But why is all that so?" which six out of ten freshmen would ask on the day of their first arrival at college.

CEMENT ITSELF A VARIABLE PRODUCT

Let us see how logic may aid to a better understanding by considering the cement by itself, separate and apart

from concrete. Cement is the finely ground product of the rotary kiln. Its characteristics vary from hour to hour both as the composition of the raw mixture varies and as the heat of the kiln changes. The speed at which the kiln is rotated and the rate at which the raw material is fed into it both affect the length of time as well as the completeness with which it is "burned." The rate at which the output of the kiln is cooled is also important, as, further, is the fineness and the quality of the raw material which is destined to become cement.

AFTER TWENTY YEARS IN SERVICE

Another case where disintegration of the concrete began even before the contractor left the job—hence the patch which has survived. The weight of the evidence indicates that this disintegration was the result of a deficiency in the quality of the cement used. Other concrete of the same mix, in the same structure, and made with cement of the same brand, is in perfect condition after nearly twenty years of exposure.

These are some of the variables, and of equal importance is the overall fact that the rotary kiln is a crude apparatus—steel could never be so simply made! As the constituent materials of the raw mixture pass through the kiln they can combine only as chance permits, because the correct number of molecules of lime cannot always be in juxtaposition with one molecule of silica just when the combining temperature is right. All of the possible combinations cannot be effected—the law of probabilities forbids so fortuitous a happening.

CEMENT FROM SOFT BURNED CLINKER PRODUCES EXCESSIVE LAITANCE

Cement then is a mixture which varies in quality and kind because of the occurrence in combination of the variable factors which have been enumerated. Some of the mixture is very good, some is average, and some may not be cement at all. On puddling this mixture with water, the water and cement combine to form new products which are the very essence of concrete, because in fact they make it what it is.

Now, if a particular cement were composed entirely of the best compounds that the rotary kiln can produce, then it could safely be used with any reasonable quantity of water, because cement made from hard, well burned clinker is only slightly affected by water during the mixing period. The poor grades made from soft clinker break down into mud, otherwise known as "laitance" almost instantly when they come into contact with water and hence the practical reason for the slogan, "Keep your water down." So there is indeed such a thing as too much water, but the freshman's logical question pointed the way to the development of the logical conclusions that, in the presence of water, the several ingredients of cement do not all behave in the same manner, and that the cements from all rotary kilns are not alike and are indeed far from being the uniform and unvarying product that they are generally supposed to be.

As logic is the helpmate of all science, so also is it the handmaiden of art. Engineering is more nearly an art than it is a science, but whichever the engineer holds it to be, he cannot escape the relentless requirements of rationalism as delineated by the abstract tests of logic. For the profession there is a test just as there is for the individual.

FOURFOLD DUTY OF THE ENGINEER

As every lawyer is an officer of the court, so every engineer represents the people. The interests of his immediate client must always be subservient to the public safety. The duty of the engineer is fourfold—he owes responsibility to the people, loyalty to his client, honesty to himself, and duty to his profession. These are the commandments which logic lays down for the engineer to follow in his every-day relationships. These the student must learn, for they go beyond the logic of science into the realm of the logic of life.

Honeycomb Gravity-Type Concrete Dams

The Suggested Design Provides Cooling and Draining Galleries

By C. E. GRUNSKY

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WITH the ever-increasing magnitude of dams for flood control, water supply, and power development, has come the necessity for examining carefully into details of design and construction which were comparatively unimportant in less massive structures. Years of observation of the behavior of finished dams of many varieties, and studies of proposed plans for innumerable others, give considerable weight to Mr. Grunsky's suggested method for taking care of the heat generated in the setting concrete. Honeycomb construction not only permits the rapid radiation of such heat but also makes possible interior drainage and inspection.

IT is a well known fact that, in the interior of massive concrete structures, there is a material rise of temperature for some time after the concrete has been placed. This fact prompted me, early last year, to attempt the tentative design of a concrete gravity dam of such a type that all parts would cool rapidly.

In preparing this design, it was kept in view that in high dams it is desirable to provide a watertight upstream face and to eliminate superfluous masonry. It was also recognized that construction joints, vertical and continuous from top to bottom, were desirable, and this arrangement was made a feature of the design. Further, the fact was taken into account that any part of such a dam, above an assumed horizontal plane, at any elevation, should be so planned as to satisfy all the requirements of a dam with its base at the level of the assumed plane.

The present tendency to attempt extreme economy in the erection of such important structures as dams is to be deplored. Above all, these structures should be simple and safe. Consequently, other factors should be given the same careful consideration that stresses are receiving, especially when failure of the structure may cause loss of life. In particular, this statement refers to the need of eliminating uplift, or at least reducing it to a minimum; and to the need for foundation studies and treatment which cannot be expressed by formula.

EFFECT OF ARCHING

Taking, for example, the gravity type of masonry dam, it is an almost universal assumption that the stability and safety of such a dam are increased by arching. Whether this is true in any particular case will depend on the character of the abutments. Furthermore, experts are not agreed as to whether the fact that a radial element of such a dam is thinner at its downstream than at its upstream face should be taken into account in estimating the maximum stress near the downstream face. It is perhaps theoretically possible to evaluate the stresses resulting from arch action when there is some deformation of a high gravity dam at full reservoir. However, the intentional reduction of gravity dimensions to bring such arch action into play may well be questioned because the dam must also be considered, in its entirety, as a plug across a gorge.

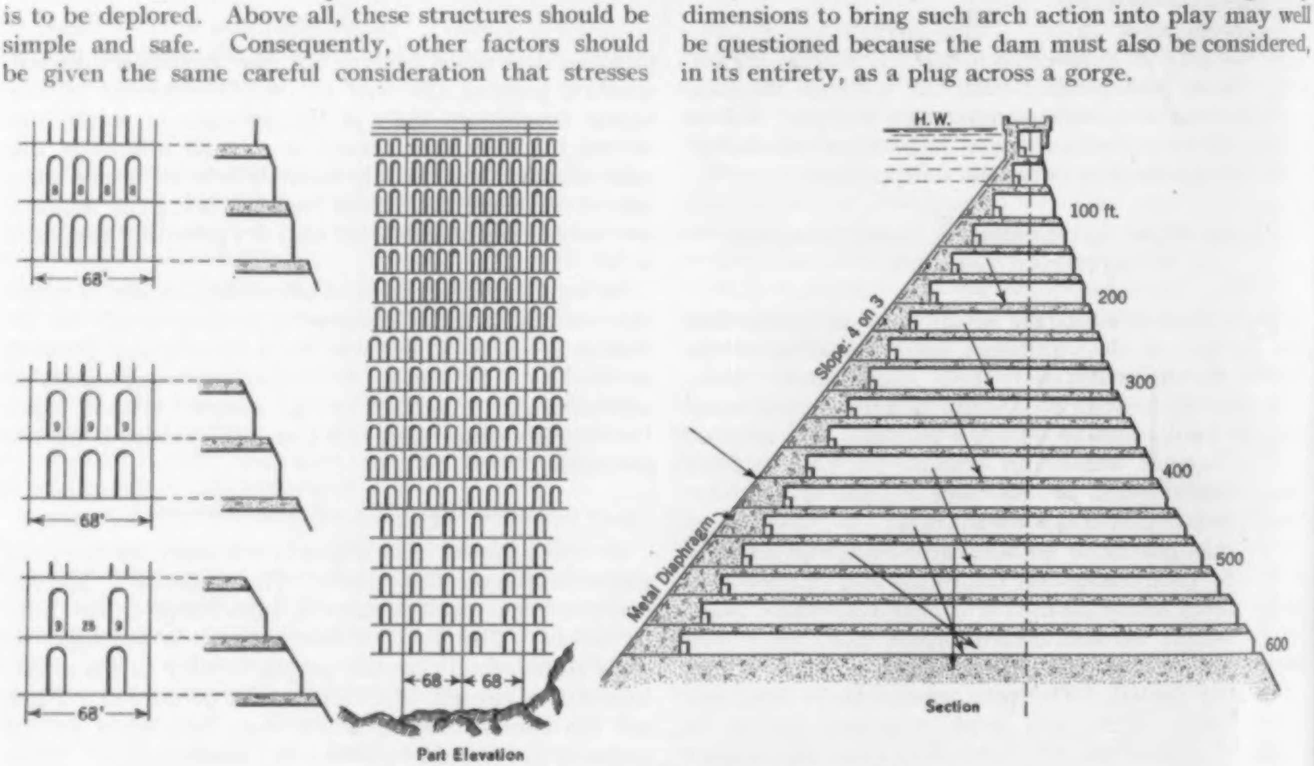

FIG. 1. CONCRETE DAM—HONEYCOMB GRAVITY TYPE
Inclined Upstream Face and Horizontal Galleries

To simplify the high gravity dam, it should be straight, not arched; to take advantage of the water pressure, treated as a load, its upstream face should be inclined; to prevent random cracking, there should be both vertical and horizontal, or near horizontal, joints, not too far apart; and finally, to keep water from permeating the concrete and reaching joints and cracks where its presence under pressure would be undesirable, either the masonry should be thoroughly drained near the upstream face or, in important cases, a metal diaphragm or its equivalent should be provided.

These considerations have led to the design shown in Fig. 1. The dimensions are, of course, tentative. This dam has an inclined upstream face, with an imbedded, impervious metal membrane. Fair-sized galleries, open at the downstream face, are provided both to reduce the quantity of masonry and to give air access to the interior so that it will carry off heat. A view of the downstream face is also included in Fig. 1. It will be noted that the vertical construction joints are 68 ft. apart. In the upper portion of the dam the galleries are four in number between these joints; lower down where more masonry is required, their number is reduced to three; and, near the bottom of a dam 600 ft. high, to two.

GALLERIES PREFERABLY INCLINED

In Fig. 1 the galleries are horizontal, but preferably they should be somewhat inclined, dropping toward the upstream face, as shown in Fig. 2. If desired, and particularly if used in a dam with a vertical or near vertical upstream face, they can be filled with water, with sand, or with broken rock, Fig. 3. In any event, drainage facilities should be provided as indicated in both Fig. 2 and Fig. 3. When the galleries remain open,

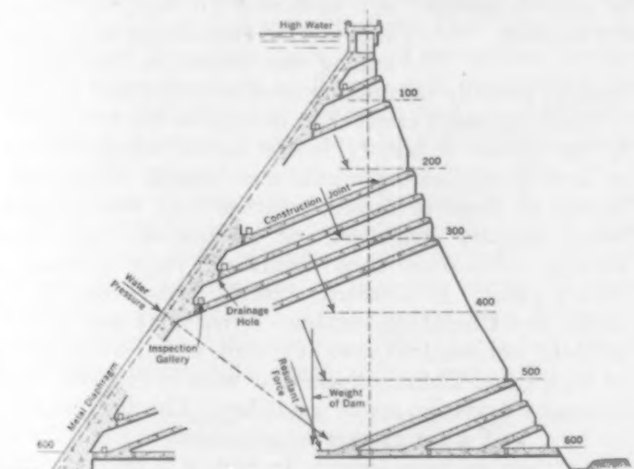

FIG. 2. HONEYCOMB GALLERIES NORMAL TO THRUST
Inclined Upstream Face and Metal Diaphragm

they should have suitable horizontal and vertical interconnections near their upstream ends to facilitate inspection and air circulation. The inclination of the galleries should in no event exceed the inclination of a plane normal to the resultant of the weight of the dam and the water pressure. This extreme inclination is indicated in Figs. 2 and 3.

At the top surface of each capping layer of concrete over a set of galleries, there should be a construction joint. In other words, this top surface should be treated

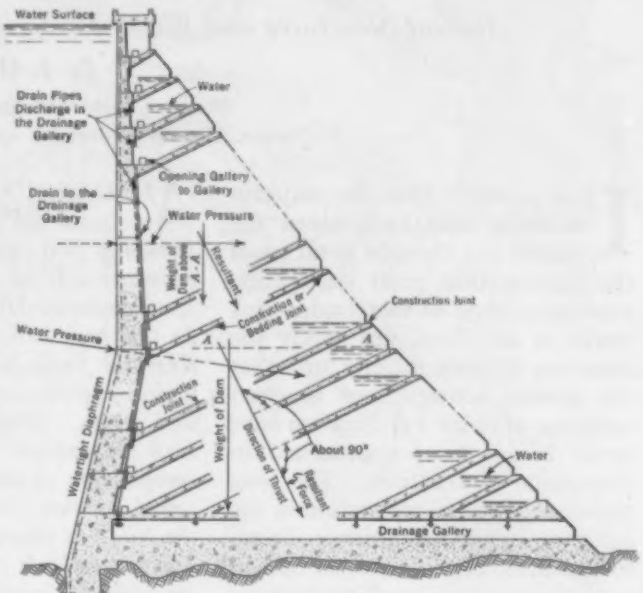

FIG. 3. VERTICAL UPSTREAM FACE
With Inclined Galleries Filled with Water

as though it were the foundation surface for the upper portion of the dam which rests on it. Near the upstream and downstream faces, such horizontal construction joints should be planned for easy sliding so that cracking through to the outer face of the dam will be held at a minimum.

WHY VERTICAL JOINTS SHOULD BE CARRIED TO THE FOUNDATIONS

In the horizontal capping over each set of galleries, reinforcing would be helpful in transmitting shrinkage and expansion stresses and thus reducing the tendency to crack. The vertical joints should, in every case, be carried to the foundation. The common practice of separating them about 70 ft. near the top of a dam, and about 140 ft. near its bottom, is objectionable because, at the point of change, where an intermediate joint terminates, the shrinkage of the two upper, narrower blocks will frequently split the lower block, thus giving the water free access to the interior even though the construction joints have all been sealed with bent copper strips or otherwise.

From one to three wells should be left open on each vertical joint, from near the top to the bottom. These should be large enough to admit a cage with an observer, and all of them should be located near the upstream face. They should remain open for several years and should then be filled with suitable material. No vertical or horizontal joint in a massive dam should ever be sealed at the downstream face. Water should there be allowed to escape freely to avoid the building up of hydrostatic pressure.

Tracing the Engineer in Early Egypt and Assyria

Ancient Structures and Works for Irrigation and Navigation Rival Modern Skill

By J. H. Gandolfo

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Numerous authors have discussed the antiquity of the profession of civil engineering, and various estimates date its origin back to fifty or sixty centuries before the Christian era. In this brief article, Mr. Gandolfo outlines the findings of numerous archeological explorations in Egypt, Chaldea, and Crete. Engineering problems of such magnitude that even now the imagination is staggered by them, were solved at that time. The channel of the Nile was changed for several hundred miles, simply to provide a building site for ancient Memphis; King Amenemhat created a regulating and storage reservoir on the Nile in Lake Moeris that could store from one million to twenty million acre-feet of water; and diversion dams on the Tigris and Euphrates rivers created canals for both irrigation and navigation, some of which carry water today. To be reminded again of the existence of these many evidences of the engineering skill of the ancients should prove interesting to every engineer.

It is probable that the majority of those who have given the matter any thought at all are of the opinion that great engineering enterprises, and in fact engineering works of any kind, are purely the creations of modern times, and that the present constructions so characteristic of today's civilization have never before been approached in magnitude and extent. The long period of practical stagnation in the development of art, science, literature, commerce, and all other human endeavor that existed throughout Europe from the fall of the Roman Empire to the beginning of the Crusades is largely responsible for this idea. Also, it is generally believed that few records of the past go back much further than the beginning of Greek and Roman civilization and that nothing is known of the world's history previous to that legendary period referred to in the fables of these countries.

This popular idea of the modernity of the science of engineering is probably correct, when such branches as mechanical engineering in its higher developments and electrical engineering are considered. However, it will surprise many of those who are interested in civil engineering construction to learn that engineering structures of great magnitude are among the earliest records of the human race. The exploration and examination of ruins in various parts of the world—such as those at Nineveh, Babylon, throughout Egypt, and in the island of Crete—have given us a wealth of information about the past; and the deciphering of even a small portion of the clay tablet "books" has shown that extensive engineering enterprises were conceived, planned, and carried out thousands of years before the Christian era. These works, many remains of which exist today, included great temples, palaces, obelisks, pyramids, walls, dams, canals, quays, lighthouses, roads, aqueducts, and irrigation, water supply, and drainage systems. In fact, the profession of civil engineering is probably among the oldest in the world's history, possibly outranking even medicine and the law.

Mound of Mugheir in Ancient Ur

One fact, which cannot fail to impress the investigator in this branch of history, is that among all the remains of ancient engineering works, none stands out so prominently as those of canals, whether they were used for water supply, irrigation, or navigation. Wherever ancient civilization once flourished, there is found a ruined canal. In Chaldea, Assyria, Babylonia, Egypt, India, and China, the remains of vast systems of ancient artificial watercourses may be traced, while, in some parts of Egypt and China, canals that were begun over three thousand years ago are in use today. The ancients seem to have had a far greater appreciation of the value of water than we have today. In fact, it is only in recent years that present development has begun to approach in magnitude and importance some of the hydraulic works of previous times.

Ancient Records Lost

Of the state of the science of engineering during these early periods, we know absolutely nothing. The consensus of opinion is that there was no real science, but that everything was done by "rule of thumb." The only foundation for this idea seems to be that no record of such a science has been discovered. However, the

fact that many arts and sciences have been for centuries, or are at present, lost arts, is no reason for saying that no records concerning them ever existed. As to engineering, the evidence still remains so that it is not difficult to imagine that the same great disasters which destroyed ancient civilizations also entirely wiped out all trace of the scientific side of engineering. Also, in the destruction of the great Alexandrian library by Caliph Omar in 640 A.D., the scientific world suffered an irreparable loss of records that doubtless would have shed much light on many perplexing historical and scientific questions of today.

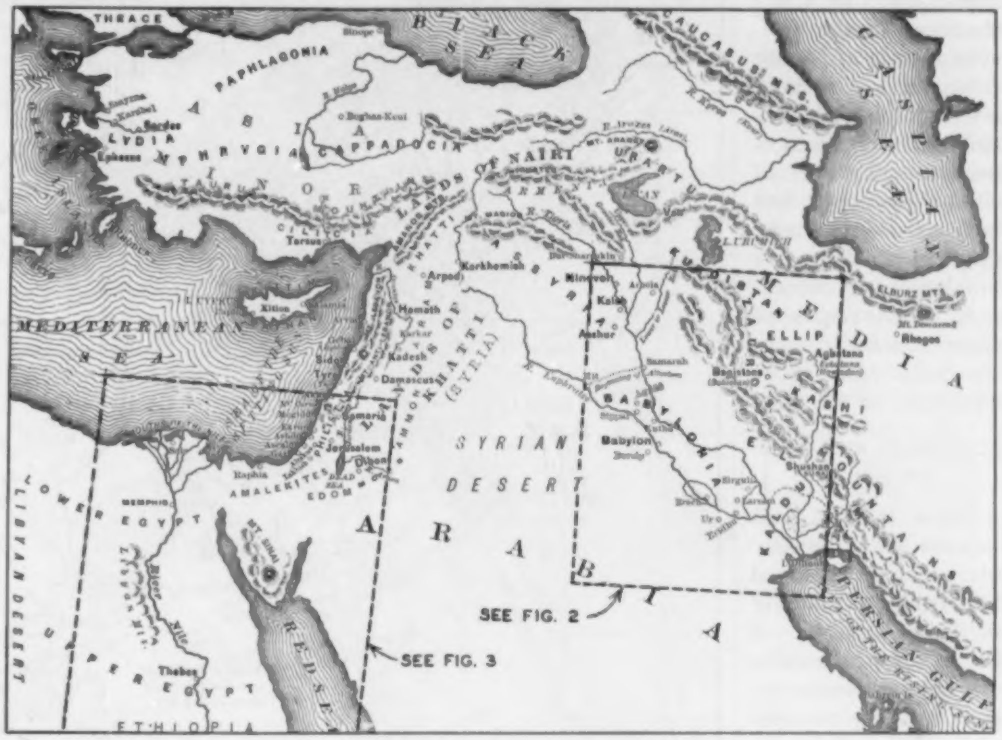


FIG. 1. THE ASSYRIAN EMPIRE

THE MYSTERY OF EARLY ENGINEERING

It is to be remembered that the dates of events occurring earlier than about 1000 B.C. are only approximate. This is especially true in regard to early Egyptian history, as the peculiar arrangement and incompleteness of its chronology make it often impossible to ascribe even closely approximate periods to many dynasties and their accompanying engineering works.

The origin and beginning of all engineering structures are shrouded in the same mystery that hides the beginnings of the human race and of our present civilization. However, from sculptures and inscriptions that have been deciphered, it is known that the engineering profession, however it may have been designated, existed at the beginning of history, that engineers were held in high esteem by reigning monarchs, and in Egypt were also connected with the priesthood, the highest class. At the very dawn of history, over forty-five centuries before the Christian era, we find two highly advanced civilizations even then fully developed—one situated in the valley of the Tigris and Euphrates Rivers, the other in the valley of the Nile, shown on the map in Fig. 1.

EARLY ENGINEERING IN THE VALLEY OF THE TIGRIS AND EUPHRATES

Parts of the valley of the two rivers are dotted with great mounds that conceal the ruins of temples and palaces, while almost endless embankments of ancient canals, sometimes 20 or 30 ft. high, cross the valley in every direction. On the map in Fig. 2 are shown many of these canals. At this remote time, Babylonia was known as the land of "Kengi"—that is, the land of reeds and canals. An inscription tells us that Urukagina was king of Shirpurla, situated in southern Babylonia, not later than 4500 B.C., and that he was engaged in building and restoring temples, and also in constructing a canal to supply his chief city, Sungir, with water.

A seated statute, found at Tello, and dating from the earliest period of Chaldean art, holds on its knees a tablet on which is engraved the plan of a fortress. A scale is also part of this "drawing," and the stylus with which the plan was traced is shown. These probably indicate that the statue is that of some great engineer. Although we know nothing of the origin of this race, or of its earlier history, we do know that these canals are worthy examples of engineering, and carry out the definition, "Engineering is the art of organizing and directing men, and of controlling the forces and materials of nature, for the benefit of the human race."

After the time represented by this statue, there comes a long period of which we know very little. It is supposed that succeeding monarchs gave more or less attention to various engineering enterprises, but there were no detailed records for about twelve hundred years. The Chaldean king, Urukh, is known to have built many tower-temples throughout southern Chaldea, about 2800 B.C. Indeed, he is believed to have adorned every one of his principal cities with one or more such edifices. The Babylonian kings, Hammurabi and Samsu-iluna; the Assyrian monarchs, Tiglath-

SEPULCHRAL VAULT AT MUGHEIR

Pileser I, Asshurnazirpal, Sargon, and Sennacherib; and the later Babylonian kings, Nabopolasser, and Nebuchadresar II, the Nebuchadnezzar of the Bible, are especially referred to in the cuneiform inscriptions as being founders of great cities, restorers and builders of great temples and palaces, or builders of great canals. The reigns of these monarchs cover the period from about 2300 B.C. to 600 B.C.

FIG. 2. CHALDEA—BABYLONIA
In Ancient Times This Valley Was Crossed in All Directions by Canals, Many of Which Are Shown

ELABORATE BUILDINGS OF BRICK

These temples and palaces were usually placed upon artificial hills composed largely of great masses of brick. In some cases the mound seems to consist of the remains of buildings of former periods, and palace has literally been built upon palace. Some of these mounds are illustrated in the accompanying photograph. Both sun-dried and kiln-dried bricks were used, the former greatly predominating. On account of the perishable nature of this material, the upper portions of the building soon crumbled into decay. However, this circumstance was of great benefit, as the lower parts of the structures, including in a number of cases the great clay-tablet libraries, were covered by the ruins of the upper portions, and thus protected for ages.

Walls were built of mud bricks of great thickness, and were often faced with kiln bricks, or with elaborately carved stone, which was brought from Lebanon as early as 3000 B.C. Even at the time of Urukh, temples and palaces were adorned with enameled bricks, alabaster, marble, and plates of gold. Also, elaborate drainage systems were provided throughout the buildings. However, it is worthy of note that practically no cement was used in these early works. Springs of bitumen exist at several localities in the region; and this material was used for cementing purposes, but walls were often dry laid. Bitumen was also used for waterproofing.

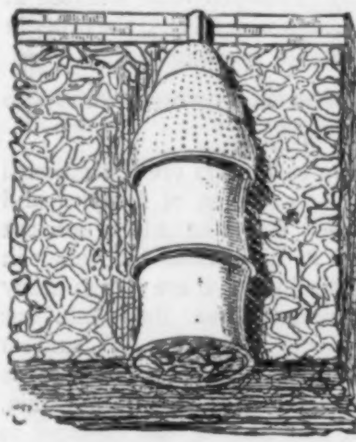
Stone slabs and timber beams were much used for roofs. Evidently the use of the arch was developed at a later date. Slaves were employed to bring in huge cedar logs from Lebanon for roof beams, and such logs were highly prized. The story of bringing in the beams for Sargon's palace at Khorsabad has been preserved for us in an ancient sculptured slab, an illustration of which is shown.

Two early Babylonian constructions are worthy of special attention—the far-famed walls of Babylon and the "Hanging Gardens." The historian, Herodotus, states that these walls, which had towers at regular intervals, were 125 ft. high and 87 ft. thick at the base. Enclosing a square 14 miles long on each side, they had 100 gates, which are believed to have been made of brass. Large kiln-dried bricks, cemented together with bitumen, and with the lower courses also bound together with reeds, were used in constructing the walls. Surrounding the city on all sides was a deep and wide moat, also lined with bricks, from which the necessary material for the walls was taken.

The Hanging Gardens, built by Nebuchadresar for his queen, Amytis, consisted of a series of terraces raised on arches, planted with trees, rare shrubs, and vines, and irrigated by water pumped from the river, the entire idea being to simulate a verdure-clad mountain.

NETWORK OF NAVIGABLE CANALS

From an engineering point of view, however, it is more for wonderful canal systems that Babylonia is noted. During the nineteenth century, Layard said: "A system of navigable canals that may excite the admiration of even the modern engineer connected together the Euphrates and the Tigris. . . . With a skill, showing no common knowledge of the art of surveying and of the principles of hydraulics, the Babylonians took advantage of the different levels



DRAIN IN A MOUND

in the plains, and of the periodical rises in the two rivers, to complete the water communication between all parts of the province. . . ." Ancient Assyrian bas-reliefs from Kouyunjik show canals for both irrigation and navigation, while probably no country, not even excepting China, ever had as complete and comprehensive a system of canals for all purposes as this ancient civilization possessed.

Hammurabi has been called the "Father of Canals," because of the number that he constructed in all parts of the land, while Samsu-iluna is supposed to have built the great canal known as Pallacopas. This began at the Euphrates, near Babylon, and flowed in a southeastern direction to the Persian Gulf, as is shown in Figs. 1 and 2. Some investigators believe this canal to have been a canalized river—at least for a great part of its length. At any rate, it was this watercourse that excited the wonder of Alexander the Great on one of his expeditions into this country.

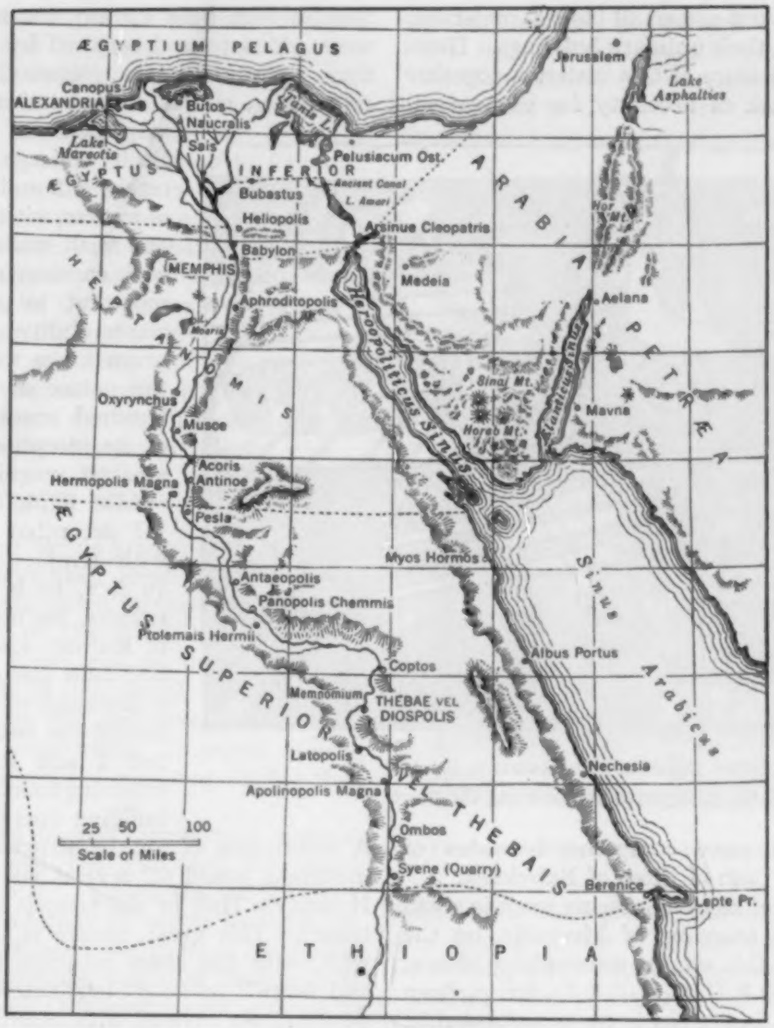
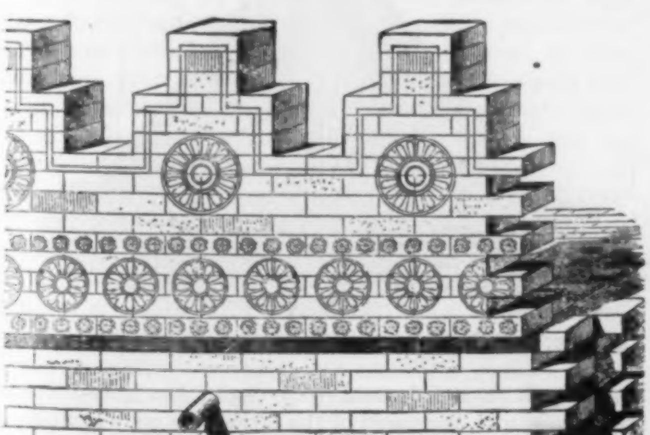


FIG. 3. MAP OF EGYPT
Location of Ancient Canal Connecting the Nile with the Red Sea and of Lake Moeris Is Indicated

The various canal systems were extended by Tiglath-Pileser I and Asshurnazirpal, the latter king having also built an aqueduct to bring a supply of water to Kalah. The water was first conveyed through a rock tunnel, and thence by an open canal to a great terrace.

According to the more complete and detailed records that exist, the reign of Sennacherib was a time of great activity in canal building. One inscription tells of 18 canals, all connecting with a single river, that were constructed by this monarch. It is also stated that he built a great canal to the city of Nineveh, although no trace of such a work has been found.

To Nebuchadresar II is ascribed the construction of the "Royal Canal," connecting the Tigris River, near Ctesiphon, with the Euphrates at Sippara. This canal is said to have been navigable for even the largest vessels of that time. At Sippara, according to Herodotus, a great basin, nearly 5 miles in circuit, and walled with stone, was built. Many other canals were also built by Nebuchadresar, and old ones were repaired and enlarged. The eastern canal of Babylon was "walled up from the bottom," which shows that lining of canals was then practiced.



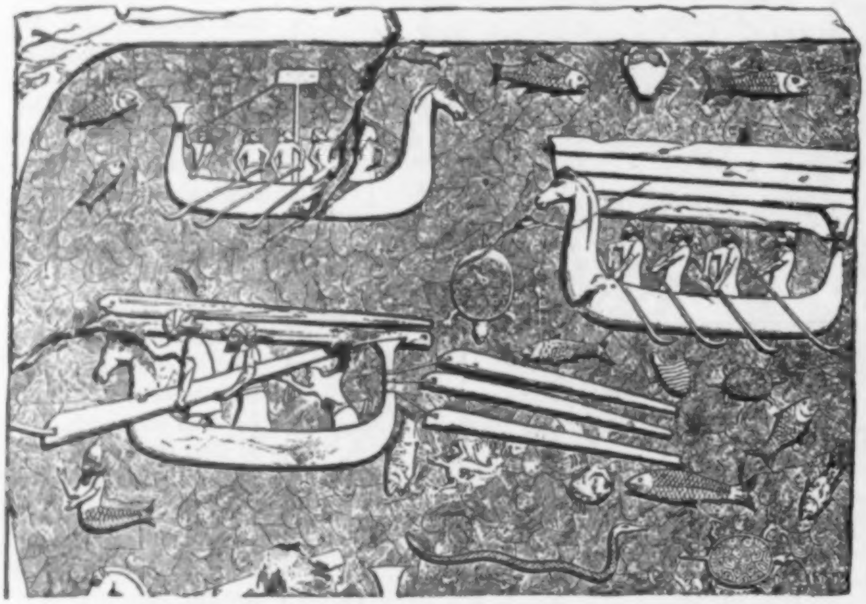
BATTLEMENTS OF TERRACED WALL AT DUR-SHARRUKIN, AND DRAIN PIPE

Stone dams were constructed to divert the water from the river into the canals, and sluice gates were used to regulate the flow. "Engines," worked by water power or beasts of burden, were used to raise water to higher levels for purposes of irrigation.

EGYPTIAN ENGINEERS USE STONE

The works of the ancient Egyptians are in many respects more wonderful than those previously described, and date back to a period in history that is perhaps even earlier. One great difference between the construction feats of these two peoples should be especially noted. The early inhabitants of the Babylonian region used brick for their principal building material, while the Egyptians, although they also used brick in large quantities, made various kinds of stone their chief building material. The former material was easily made and handled at the site of the works, but the latter had to be quarried, dressed, transported, and then erected. More-

over, the Egyptians did not use small blocks, preferring huge monoliths for even their ordinary buildings. However, the more durable nature of this material, together with the consequent lack of necessity for excavation, has given us a much more comprehensive idea of Egyptian constructions than of those of Babylonia.



Transporting Timbers for Sargon's Palace
The God Ea Is Depicted as Escorting the Fleet

The earliest account of any engineering work is given in connection with the founding of Memphis, on the Nile. The building of this city is ascribed to Menes, various dates, from 5700 B.C. to 2700 B.C., having been fixed for the time. The earlier one is the more probable. At any rate, there is no doubt that this monarch, in order to obtain better irrigation for lower Egypt or, as some have thought, simply to secure a more favorable location for Memphis, changed the course of the Nile from the western side of the valley to the eastern side. To accomplish this purpose, he built an immense dam or dyke across the river near the Libyan Hills, which caused the river to seek a new channel. The old bed was then filled in and the city of Memphis built on the site. As early as 3700 B.C., there existed in Egypt a public office known as the "Superintendent of Works," and those holding this position were considered high officials.

Pyramids, Palaces, and Obelisks

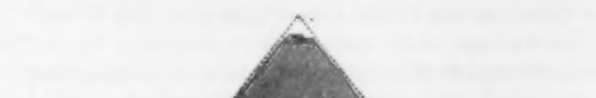
When Egypt is mentioned, one's first thought is naturally of the Pyramids, which are so well known as to need very little comment. The Great Pyramid, the largest of the group, covered 13 acres and was 480 ft. high. It was built by Cheops, of the Fourth Dynasty, who is said to have employed 100,000 men for 20 years in its construction, after having spent 10 years in preparatory work. One fact in regard to the larger pyramids should be mentioned, which is that the original surfaces were of polished stone, laid without the use of mortar, and with joints very closely fitted.

The ruins of temples and palaces at Luxor, Philae, Karnak, and other sites have for many years excited the wonder of travelers. It is not supposed that these temples were built by any one monarch, but that they were added to and repaired by succeeding kings, until they comprised an aggregation of approaches, halls, colonnades, courts, and chambers that has never been surpassed in size or magnificence. Built of large blocks of stone, accurately cut and fitted without the use of mortar, with joints only $^1/_8$ in. thick, and with walls and columns covered with carvings and hieroglyphics, they represent an engineering feat of no mean ability. It is estimated that seven kings were engaged in building the palace at Karnak and that five hundred years elapsed from the time of its inception to the period of its greatest magnificence.

Like Urukh of Chaldea, Thothmes III decorated all his principal cities with temples, palaces, and obelisks. In fact, he is noted for his splendid edifices, having added to the Temple of Karnak and the Palace of Luxor, and built the grand avenue lined with a thousand colossal sphinxes, that connected the two. But it remained for Seti I and Rameses II to put the crowning touch to the temple and palace building operations of the Pharaohs. A description of all the structures built by these two monarchs would fill several volumes, so only the great Hypostyle Hall in the temple at Karnak can be mentioned. This great temple is 170 ft. long and 329 ft. wide, with 134 stone columns, from 40 to 70 ft. high, and from 8 to 12 ft. in diameter. Walls and columns were entirely covered with beautifully colored sculptures and hieroglyphics.

Egyptian Irrigation Engineering

The value of the waters of the Nile for both fertilization and irrigation was early appreciated by the Egyptians, who built elaborate systems of irrigation canals. It is not known who began the construction of these works, but most of the large ones were built during the Twelfth Dynasty. One of the earliest accounts is that of the building of Lake Moeris, shown on the map in Fig. 3. During the reign of Amenemhat III, there



Section Through the Great Pyramid of Cheops

was an unaccountable failure in the periodic rise and overflow of the Nile; and to guard against the disastrous consequences of another such failure, he constructed this great artificial reservoir. A canal 8 miles long, 160 ft. wide, and 30 ft. deep was built from the Nile to the natural depression in what is now the Fayoum. Through this canal, the surplus flood waters of the river were brought and stored for future use within a lake, 14 miles long, 7 or 8 miles wide, and probably 80 ft. deep in places. Some investigators have gone so far as to state that the entire area of the Fayoum was used as a reservoir. The embankments and dykes that confined the water were built of both earth and masonry, and the flow of the water was controlled by sluice gates. One author states that there was also a source of communication with the river by means of a tunnel.

ANCIENT METHODS STILL USED

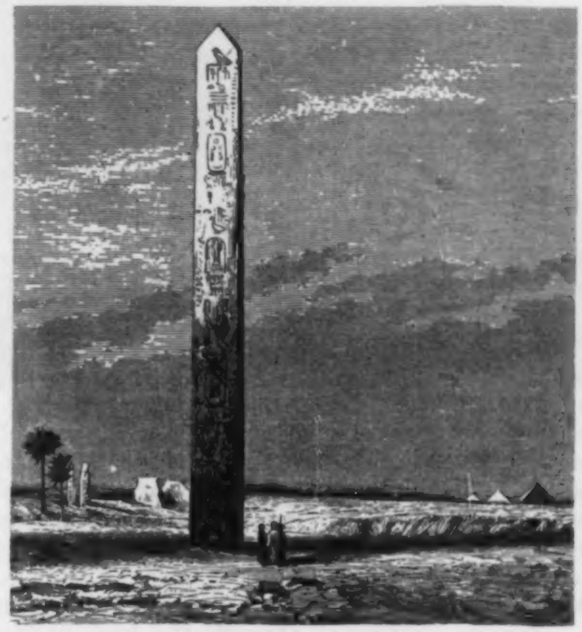
A network of irrigation canals gradually spread over the entire country. Where their level was above that of the river, the water was raised to them by means of the *shaduf*, the *sakiyeh*, or the *natali*—methods that originated in these early times, and are in use in Egypt at the present day. Some of these canals are so ancient that they now have more the appearance of natural rivers than of artificial waterways. However, it was largely to this complete system of irrigating ditches that Egypt owed her greatness.

It has been determined beyond doubt that a canal connected the Red Sea with the Nile at a very early date. As far back as 1700 B.C., Queen Hatasu is known to have sent several expeditions by water to Punt, on the west coast of Africa. Since it seems hardly probable that her fleet circumnavigated the continent several times, it has been concluded that such a canal existed at least as early as this period. In fact, there are authoritative records that it was built or restored by Seti I. Leaving the Nile near Bubastus, it passed through the Wadi Tumulat and emptied into the Bitter Lakes which, it is now supposed, were part of the Red Sea at this time. Necho, Darius, Hystaspis, Ptolemy I, Trajan, and Caliph Omar are all said to have repaired the canal.

PROOFS OF AMAZING SKILL

Before leaving Egypt, a few words should be said about its mechanical triumphs. Although its engineering feats were carried out by captives and slaves, to feed and house, even in the rudest manner, and to guard and police an army of 100,000 discontented men, who were for 20 years engaged in unproductive labor, was an engineering problem that would tax the resources of any nation. The Great Pyramid contains 3,500,000 cu. yd., a large part of which is granite, some of the stones being single blocks, 30 ft. long, 5 ft. wide, and 4 ft. high. This material was probably brought from the quarries at Syene, and carried 500 miles to its present position. It must, then, have required skill of a high degree to quarry, transport, and erect the obelisks, those huge single blocks of stone, which were 7 or 8 ft. square at the base, and often over 100 ft. high. To cut the rock-hewn temples and sepulchres of the later Pharaohs, would be a difficult undertaking, even with the tools and appliances of today. Among outstanding examples of such skill are the colossal statues at Thebes, which are 47 ft. high and cut from a single block of granite.

Mention should also be made of the recent discoveries in the island of Crete, where there are remains of a fully developed civilization that existed as early as 2800 B.C.



OBELISK OF USURTASEN I, ON THE SITE OF HELIOPOLIS

Aside from the general plan and construction of such vast palaces as that of the Cretan king, Minos, the most interesting feature to the engineer is the complete and "modern" drainage system that was designed and built for this edifice. Its main features, which were all used for a storm water system, are a stone conduit lined with smooth cement, stone shafts leading to this conduit, manholes for inspecting the main drains, and terra cotta pipes of a pattern similar to those made today. There was also a complete system of latrines and other sanitary structures.

To attempt to give full descriptions of even one class of structure would fill volumes, even though the record is dim and broken and can only be traced by patient study of half-effaced inscriptions and sculptures, and ruins that have been exposed for thousands of years to the destroying influences of man and nature. Enough has been told, however, to show that over six thousand years ago "engineers," by whatever name they were then known, planned and constructed great works that rival those of today, and that they have left few records of their science, and hardly a trace of the means by which that science was converted into practical use.

For those who are interested in the further study of ancient engineering, there are various volumes on the subject. Among these are *The Technical Arts and Sciences of the Ancients* by Albert Neuburger, recently translated from the German, and *Ancient and Modern Engineering* by William H. Burr, M. Am. Soc. C.E.

Acknowledgment is made to G. P. Putnam's Sons for permission to reproduce the illustrations and maps used in this article from *The Story of the Nations*, published in 1887.

Road Building on Dredger Fill

Chicago's "Century of Progress" Uses Rock Asphalt Surface on Macadam Foundation

By S. F. Ferguson

Associate Member American Society of Civil Engineers
Chief Engineer, Kentucky Rock Asphalt Company, Louisville, Ky.

Building permanent major traffic boulevards on a sub-base of Lake Michigan dredger fill, not stable enough to support even a truck, was the problem which had to be faced by the engineers who are developing the plan to accommodate traffic to the Chicago Fair in 1933. After considering various types, a water-bound limestone macadam sub-base, with a rock asphalt wearing surface, was selected. It is reported to be giving excellent service under traffic, which is already intensive. Considering the heavy usage which it is still to receive, highway engineers will watch this section of roadway with considerable interest.

CHICAGO is busily engaged in the construction of a mammoth stage setting on its South Park Lake Shore, from which to show to the world in 1933 the periodic peaks in the last century's march of history and science. The fair, "A Century of Progress," extends in its entirety from Monroe Street southward along the lake front to 47th Street, but utilizes more intensively the area between Roosevelt Road and 39th Street. It will include the classical structures of the Shedd Aquarium, the Adler Planetarium, and the Soldier Field Stadium.

Starting just at the southwest corner of the stadium and extending southward through the area to 39th Street, a new system of highways has just been completed in record time. Every highway construction engineer has, at some time, dreamed of the ideal job on which a railroad paralleled the road grade within shoveling distance. Necessity, the constant challenger of engineering ingenuity, compelled the contractor to materialize such a dream on this job by building his own railroad.

A SPECIAL CONSTRUCTION TRACK PROVIDED

All of the terrain east of the Illinois Central Railroad tracks at this point is made ground, with a sub-base of sand pumped in from Lake Michigan. It was not sufficiently stable to permit the use of trucks for the transportation of road-building material. Time being a factor, which added hazards to truck transportation, a standard-gage track of 90-lb. rails, at an approximate cost of $21,000, was laid down a 14-ft. center strip between the two 35-ft. pavements designed to handle north and southbound traffic around the western limits of the fair area. This 14-ft. space between the drives will later be filled and planted. From the track, crushed stone was unloaded at the rate of 50 to 60 cars per day with a battery of eight truck and caterpillar cranes. The screenings, in turn, were unloaded by the same method. Switching and spotting of cars was done with caterpillar tractors.

The road bases were constructed in one 6-in. course and one 4-in. course (10 in. compacted) of water-bound macadam. Because these roadways were to be built on made ground, a non-rigid type of base was selected. Crushed limestone of excellent bonding qualities being available at low cost, a water-bound macadam base was chosen. This base was laid in two courses, because experience has shown that a 6-in. course of crushed stone

Unloading the Macadam Sub-Base

is the greatest thickness which may be properly choked by screenings, and unless a water-bound macadam base is thoroughly choked, internal wear very quickly rounds

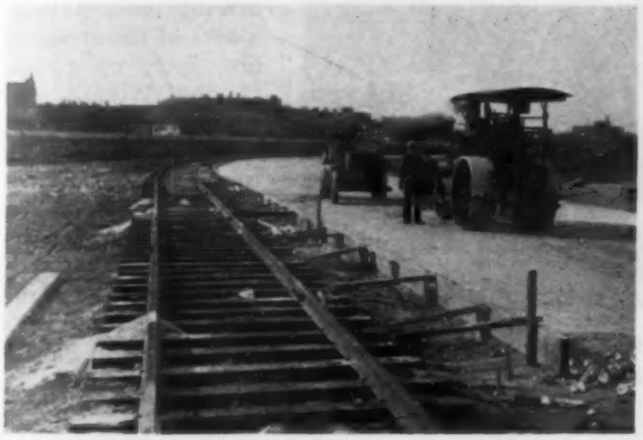
Fig. 1. Road Construction Plan, "A Century of Progress,"

off the angular stone and causes settlement of the surface.

ASPHALT WEARING SURFACE CHOSEN

A non-rigid type of base, built on made ground, will settle in a very irregular manner under such traffic as may be expected on these roadways, hence a surfacing material had to be used which was sufficiently flexible to follow the settlements without breaking. The surfacing material, or wearing surface chosen was a rock asphalt, in this case a pure silica sandstone completely impregnated with natural asphalt. It is mined in its native condition in Kentucky, hence its trade name, Kyrock. This material was selected as more nearly meeting the requirement than any other type. It is simply crushed fine, laid cold, and rolled to a thickness of $1^1/_2$ in. Immediately after rolling it is ready for traffic. Continued traffic compacts a thin crust on the surface, somewhat more dense than the material beneath. Thus it becomes waterproof and resilient. The material has the further characteristics of stability against creeping and good traction, wet or dry.

NORTH FROM 23D STREET, OUTER DRIVE COMPLETE ON RIGHT
Inner Drive Macadam Base at Left



ROLLING THE EAST ROADWAY AND GRADING THE WEST

In 1926, at the time of building the first road in the reclaimed area, various types of construction were considered for this made ground, and the amount of intensive traffic which a highway through this area would have to withstand was estimated. After a year's test in service, the two-course (10-in. compacted), water-bound macadam with rock asphalt top was selected as the type best adapted to the conditions and service. The Leif Eriksen, or Outer Drive, a 70-ft. speedway carrying both north- and southbound traffic, was subsequently built of this type, as was the 40-ft. connecting highway south of the Soldier Field Stadium. The satisfactory service and negligible maintenance required for these roads since their construction recommended the continuance of the type for the World's Fair area.

To facilitate the laying of the wearing surface at the low temperatures then prevailing, the material was steamed in the cars on the Soldier Field Stadium switch. A 100-hp. boiler, operating with a steam pressure of 100 lb., was needed, using 20 jets in each end of a car and steaming for from $2^1/_2$ to 3 hours. In general practice this material is laid cold, but temperatures lower then 50 deg. will retard unloading and spreading. Allowable temperatures for steaming range between a maximum of 250 deg. and a minimum of not less than 150 deg.

After steaming, the material was unloaded with a clamshell into trucks, hauled under tarpaulin to the section being surfaced, and dumped directly on the base

THE INNER DRIVE NORTH FROM 38TH STREET

STEAM HEATING THE ASPHALTIC WEARING SURFACE

behind the shovelers. The average temperature of the material at this point was about 180 deg.

A SIMPLIFIED PROCEDURE

Special methods were developed in laying the wearing surface and were found to expedite the work. To regulate the thickness of the loose material, steel strips $^1/_4$ in. by $2^1/_4$ in. by 18 ft., with a 12-in. section on one end bent into a T to prevent overturning, were laid edgewise on the base, on 3-ft. centers parallel to the center line. Workmen operating angle-iron lutes back and forth over these strips raked the loose material to even grade and uniform density. The depth gages were pulled forward as the spreading progressed.

SPREADING THE ASPHALT ON THE WEST ROADWAY
North from 37th Street

Irregularities left by the luters were corrected by 8-ft. wooden lutes operated at 45 and 90-deg. angles to the center line. On the sides of the roadway were forms made of 2 by 4-in. and 1 by 4-in. pieces spiked together at right angles. The 2 by 4-in. laying flat served the double purpose of a form and a depth gage for the edges of the surface, and the 1 by 4-in. upright on the outer edge of the 2 by 4-in. flat, prevented the waste of material over the edge while raking. These forms, like the metal depth gages, were moved forward as the spreading progressed.

Immediately after the first rolling with an 8-ton tandem roller, the surface was swept with the sifted rock asphalt and rolled with a 3-wheel 12-ton roller. This final rolling was completed within 45 minutes from the time the material was spread and raked to grade. Following these methods, a crew of 34, including two base sweepers and the two rollers, laid 7,080 sq. yd. of surfacing ($1^1/_2$ in. compacted) in one day. This is equivalent to 1,820 lin. ft. of pavement 35 ft. wide.

Including the widening of the existing southbound drive, the completed highway system through the park area will aggregate one-third of a million square yards of this type of construction. The famous Leif Eriksen Drive, skirting the lake shore, popularly known as the Outer Drive, a 70-ft. speedway of the same construction as that laid from 1926 to 1928, will be incorporated into the fair grounds as the axial highway. The Administration Building and the Transportation Building, marvels of the newest in construction details, are nearing completion; others of the group are now going up. Plans of the World's Fair staff, now rapidly developing to completion, indicate that this favored area on Chicago's South Park Lake Shore will be one of the most interesting and informative spots in the world in 1933.

REMOVING THE CONSTRUCTION TRACK
South from 38th Street

Large Turnover in City Managerships

An Analysis of Salaries Paid and Tenure of Office

By Arthur Richards

Member American Society of Civil Engineers
Member of the Society's Committee on Salaries
Assistant Engineer, State Water Policy Commission, Trenton, N.J.

Wherever possible, in the course of the investigations now being conducted by the Committee on Salaries, data are secured on remuneration and conditions of service in other professions. It is hoped that sufficient information of this type will be obtained to make intelligent comparisons between the situation in the engineering profession and in other fields. Recently, the Chamber of Commerce of the United States published a report on "The City Manager Plan of Municipal Government," from which the following partial analysis is made regarding salaries paid to city managers, and their tenure of office.

Is it true, as is often stated, that partisan politics is to blame for the relatively short periods of service of city managers? In the following partial analysis of a report published by the U.S. Chamber of Commerce, Mr. Richards supports his views on this subject by some interesting statistics. He also considers the question as to how the salaries paid to city managers compare with those received by city engineers and state highway engineers. This article gives an enlightening preview of the results of one phase of the investigation which is now being made by the Society's Committee on Salaries.

The analysis is based only on the data which apply to the 404 cities which had managers in 1930; computations do not include the 40 or more cities which have abandoned this form of government. Practically all the cities which now have managers are included in the charts.

The impression prevails that the position of city manager is one of short duration, due to the influence of partisan politics. The charts rather plainly show that politics, in the partisan sense, is not the primary reason for this large turnover. Politics, as it relates to the management of government, has no doubt had a large influence, but this has been exercised mainly in securing the release of managers who were not fully qualified to hold such positions.

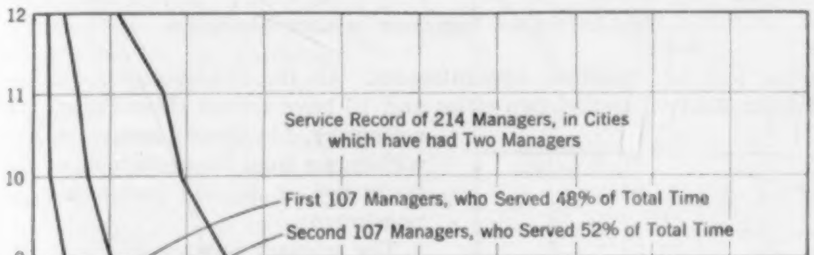


Fig. 1. Length of Service of City Managers
Data to March 1930 in 217 Cities

Ability Affects Tenure

Data used in the computation of Table I show that there had been a total of 1,018 managers up to the time of the report, March 1930. Of this number, 614 were no longer in office, an occupation loss of 60 per cent. It also is inter-

Table I. Data on City Managers in 1930

Present Managers and Cities Served		Cities Served by One or More Managers	
Number of Managers	Cities Served	Number of Cities	Number of Managers
328	1	110	1
54	2	107	2
16	3	70	3
2	4	55	4
2	5	30	5
2	6	17	6
		4	7
404		6	8
		4	9
		1	10
		404	

Distribution of Managers According to Population of Cities Served

Size of Cities Pop. in Thousands	Percentage Total Number of Managers	Percentage in Cities This Size or Larger
5 and less	32.0	100.0
5 to 10	26.0	68.0
10 to 20	19.5	42.0
20 to 40	9.4	22.5
40 to 60	5.2	13.1
60 to 100	4.5	7.9
100 to 200	1.7	3.4
200 to 300	0.5	1.7
Over 300	1.2	1.2
	100.0	

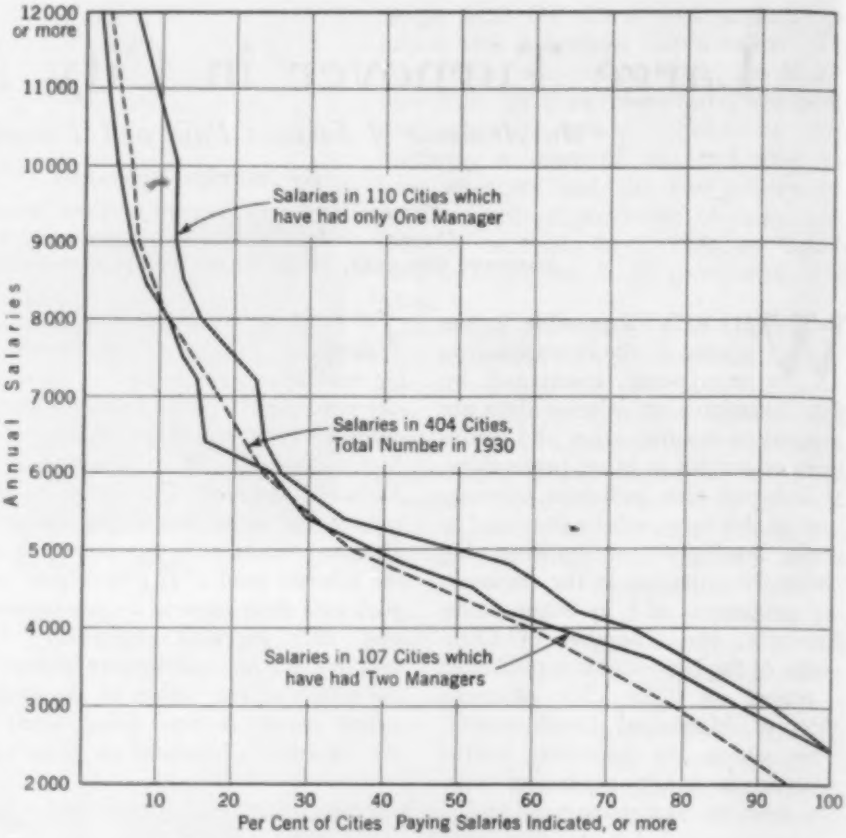


FIG. 3. SALARY INCREASES OF CITY MANAGERS

esting to note that, of the 404 present managers, 328 are serving for the first time. On the other hand, 110 who were first appointees, with no previous experience, have remained in office for the entire period that this form of government has been in effect in their cities. The terms of these men are graphically shown in Fig. 1. For example, 79 per cent of them have been in office for three years or more, 50 per cent for five years or more, and 2 per cent for 15 years or more. This would indicate that qualified managers can retain their positions as long as they wish.

DATA ON CITIES SERVED

These 110 cities which have had only one manager represent a combined total service of 654 years. Among the managers, 74 per cent are serving for the first time, 17 per cent have served two cities, 6 per cent three cities, and 3 per cent have served four or more cities. Of the total time these cities have had the manager form of government, only 15 per cent have been served by managers who had served elsewhere.

In the 107 cities which have had two managers, it is noted in Fig. 1 that about 50 per cent of the 214 managers served four or more years, which is a very satisfactory record for purely political appointments. Of the 214 managers, 54 have served two cities and 16 have served three cities. The remainder, 144 former managers, have withdrawn from the profession, as they could not or did not secure new appointments.

The primary purpose of Fig. 1 is to show by analysis and inference that presumably qualified managers remain in office for relatively long periods of time.

MORTALITY IS HIGH

It may also be readily proved that relatively few city managers persist, or survive, in office. Table II bears out this point. Managers serving for the first time, but succeeding others, are properly omitted from the final per cent.

From the fact that only 23 per cent of the first appointees selected by cities continue to remain in office, it is quite evident that many first appointees were not qualified by training and experience to perform the technical and administrative duties required of a city manager. On the other hand, it is clear that officials on the various city councils were not qualified to make proper selections of city managers.

Studies of salaries, by various classi-

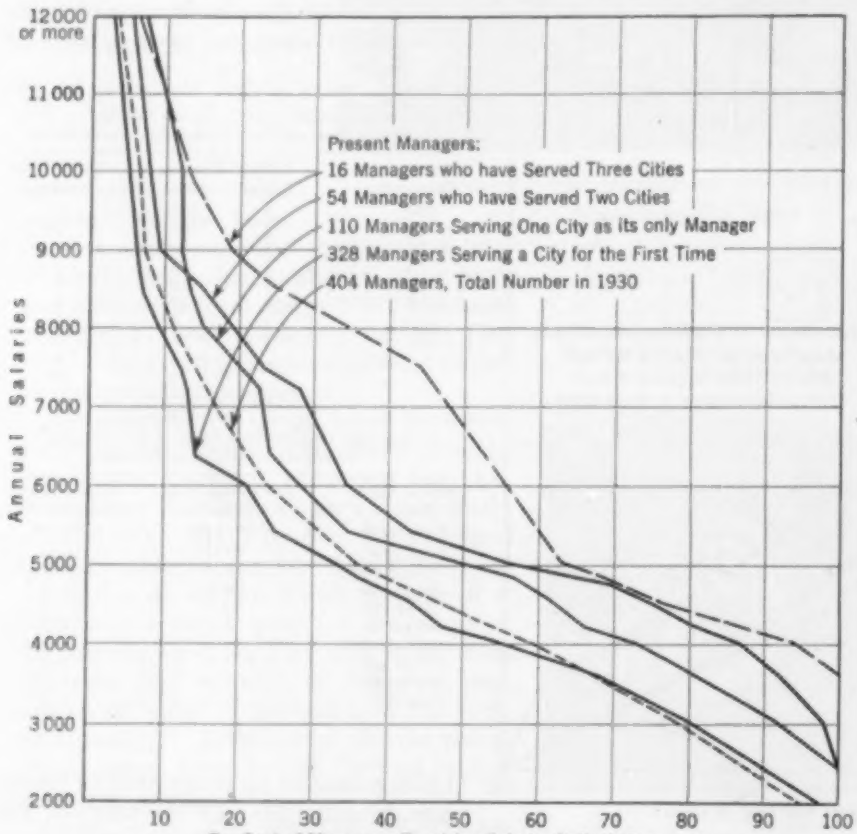


FIG. 2. RELATION BETWEEN SALARIES PAID AND NUMBER OF CITIES SERVED

fications, have given the results plotted in the several service charts. As is shown in Fig. 2, the 110 original managers receive salaries well above the average for managers. Salaries increase with length of service, whether service has been in either one or more cities. The 54 and 16 managers who have served more than one city have evidently been promoted to better positions.

Primarily, Fig. 3 shows that the cities which have had only one manager pay higher salaries than cities which have had more than one. This would indicate that the 110 original managers have rendered satisfactory service and have received salary increases.

In Fig. 4 is given graphically the number of managers serving in cities of various populations, and their annual salary. As a rule, salaries increase with population served. This chart is based on percentage, but distribution for any particular salary can be calculated, as in Table III.

A comparison between salaries paid to city managers, state highway engineers, and city engineers shows that the highway engineers receive salaries below those paid to managers in cities of from 40,000 to 60,000 population, and that the city engineers receive salaries comparable to those received by managers in cities of from 5,000 to 10,000 population.

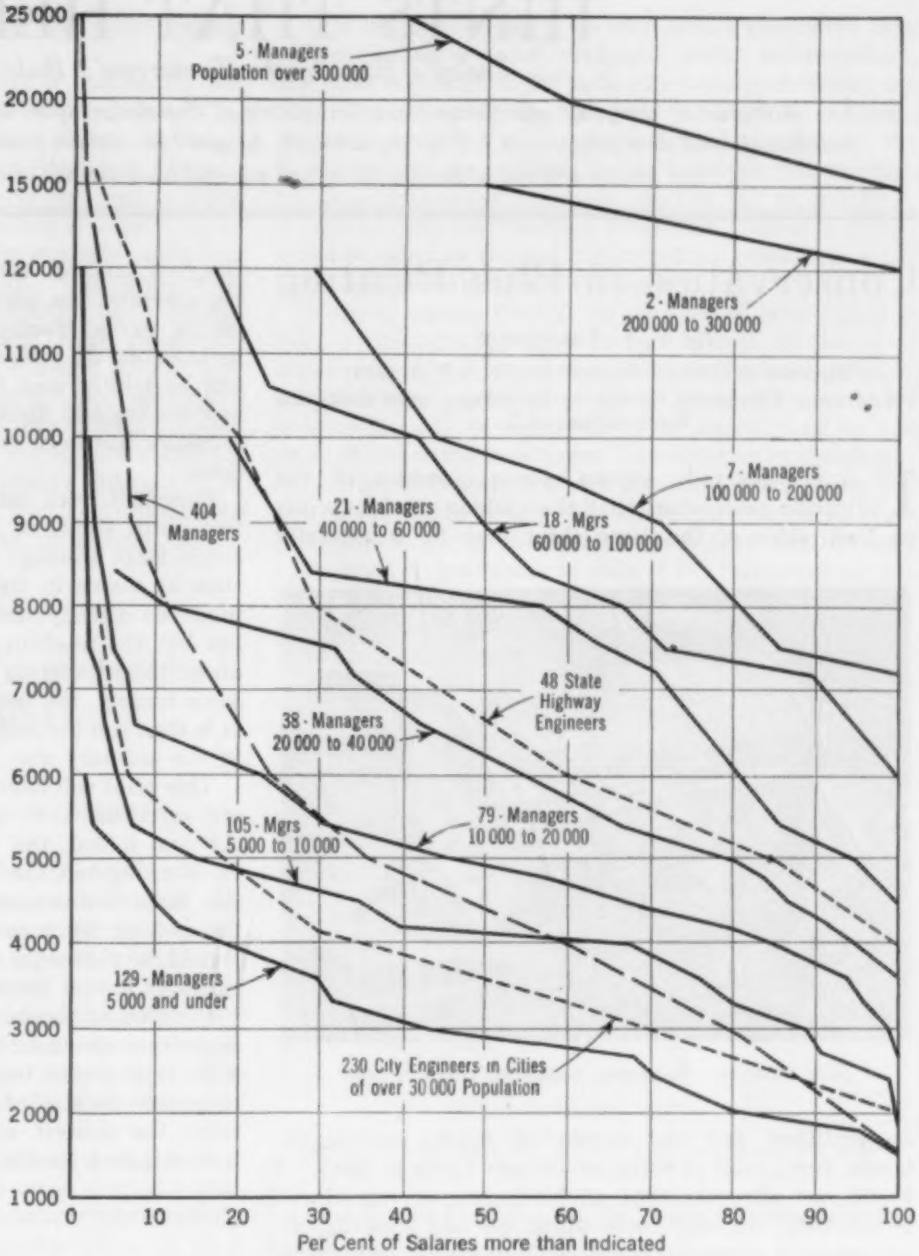


Fig. 4. Annual Salaries of City Managers in 1930
According to Population of Cities Served

If it is granted that the salaries paid to city managers are equitable for services rendered, then it might be inferred that those paid to chief engineers are not equitable. The information shown in the charts should be of interest to all engineers, and this preview, as it were, is an indication of some of the data which will be presented in the final report of the committee.

Table II. Record of Experienced Managers

Present managers, under first or subsequent appointment	186	
Present managers under first appointment in cities previously served by others	218	
Total number of present managers		404
Total managers on record	1,018	
New managers	218	
Managers retired and in continuous service		800
Per cent in continuous service (186 ÷ 800)	23 per cent	
Per cent withdrawn [(800 − 186) ÷ 800]	77 per cent	

Table III. Distribution of Managers Receiving $5,000 per Annum or More

Classification According to Population of Cities	Number of Cities
5,000 and less	9
5,000 to 10,000	16
10,000 to 20,000	36
20,000 to 40,000	30
40,000 to 60,000	20
60,000 to 100,000	18
100,000 to 200,000	7
200,000 to 300,000	2
Over 300,000	5
All managers	143

HINTS THAT HELP

Today's Expedient—Tomorrow's Rule

The minutiae of everyday experience comprise a store of knowledge upon which we depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from young and old alike, should afford general pleasure not unmixed with profit.

Conservation in Blue Printing

By F. J. Trumpour

Member American Society of Civil Engineers
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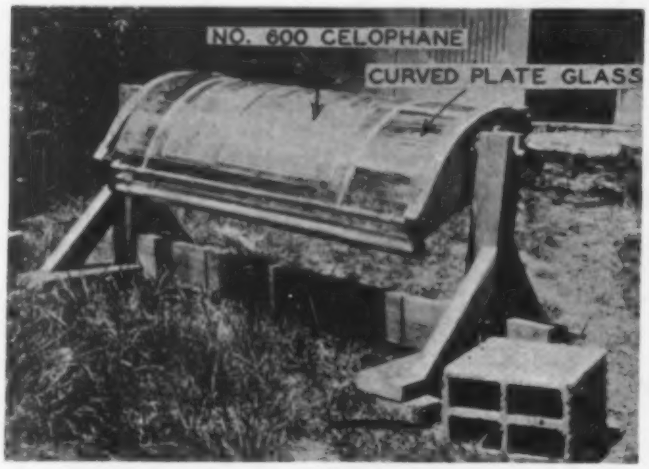
It is not generally known among members of the scientific professions that the making of blueprints on both sides of the same sheet may be successfully



Sun Printing Machine, Exposing Convex Side

accomplished, and that worthwhile results may be obtained from such printing of certain kinds of data. I would not advocate that all blueprints be reproduced in this way, but only those whose use and final disposition make it advantageous from an economic standpoint. It will be found practical to employ this method for all standard-size drawings used for filling purposes, thus making it possible to bind together all data pertaining to any one subject, such as railroad and highway land plans and maps, drawings of standard structures, architectural plans, drafting-room data, and reports on engineering and scientific subjects.

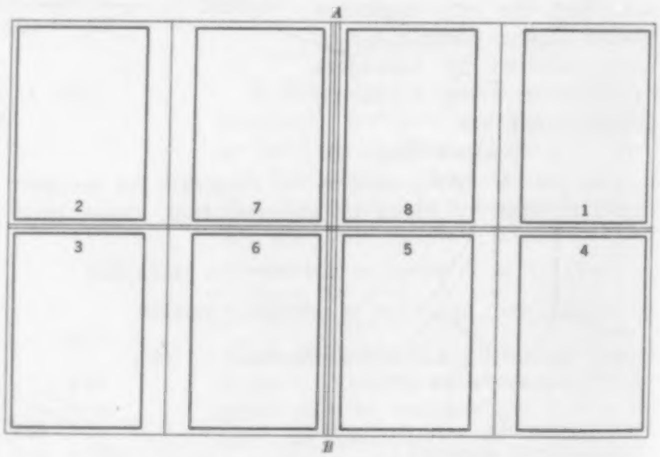
The kinds of negatives which can be used include tracings, Van Dyke negatives, thin typewritten sheets, and photographic films, the size of the negative being limited only by the size of the printing machine. Any combination of negatives may be used on one sheet, as in printing pamphlets having descriptive matter along with drawings or photographs.

In making the prints, the double-coated paper is cut the same size as the negative used. When reproducing single, standard-size tracings, the first one is placed on the cut sheet of paper and run through the electric printing machine. While the exposure is being made, the second tracing is placed on the board, face down. When the first tracing, with its exposed paper, comes from the machine, the unexposed side of the paper is placed on the second tracing, the border lines of which should be matched up with those of the exposed sheet. These can be faintly seen through the paper by holding the new tracing and sheet up to the light. After the second exposure has been made, the print is washed on both sides.

Pamphlet work can be conveniently done with either two, four, eight, or more page layouts arranged on a single large tracing. The arrangement of the work is then as shown in the sketch, and the first exposure is made as already described. When the exposed sheet has left the machine, it is turned over by revolving it about the registering line *AB*, and placed again on the same tracing, the border lines being matched as before. It is then run through the machine and the print washed in the ordinary way.

This print will have two complete copies of the tracing, one on either side, and, when it is cut along the line *AB* and folded, the pages will follow in proper order. In blocking out the small pages on the large tracing, the same layouts are used as in the printing trades for making up forms for book work. The line *AB* should be shown on all multi-page tracings, as it is the turnover line of the form.

If different classes of negatives are used on a multi-page form, the more translucent ones should be covered with thin sheets to retard the action of the light in order that the tone of all pages may be the same. Naturally, the densest negative will govern the length of time required for the exposure.



Layout for Eight-Page Pamphlet

In the accompanying photograph is shown a simple, cheap, and easily operated sun printing machine. Its transparent celluloid curtain permits the making of both exposures by simply revolving the glass printing

unit without removing the tracings and paper, either with single or multi-page forms.

Blueprints made in this way give a number of advantages: savings in the amount of paper used, including the various elements entering into the manufacture of the paper; a 100 per cent utilization of the surface of the paper; a reduction of 50 per cent in filing equipment and space required; a saving of from 20 to 40 per cent in cost over those printed on one side only; and economy in postage when mailing. The method is also advantageous from the standpoint of handling, affording savings in both effort and time consumed.

Both blueprint paper and cloth come in rolls or cut sheets coated on both sides. They are standard commercial products. More complete information on this method, with examples of some of the results obtained, is on file in the Engineering Societies Library. Its application to the blue printing of Van Dyke negatives and pamphlets is there illustrated in greater detail.

Universal Leveling Rod Reduces Calculations

By Fred Morley

Member American Society of Civil Engineers

To shorten the time required for the field work of cross sectioning, and to eliminate much of the tedious arithmetical labor in reducing profile level notes, I have designed and constructed a type of leveling rod with a flexible steel tape graduation added. To a large extent, the calculations are made mechanically by setting the index of the flexible rod at the proper place in relation to the cross hair of the instrument, after which the readings on the tape give the desired results directly.

This rod is between 10 and 11 ft. in length, and is $1^1/_2$ in. wide by 2 or $2^1/_8$ in. thick in cross section. For convenience in transportation, it can be made in two half lengths which are rigidly joined together when in use. The face of the rod is in every respect identical with that of the self-reading Philadelphia rod, with the same graduation into feet, tenths, and hundredths, the same numbering, and the same vernier target.

It is designed to carry, on each side, a graduated tape ribbon of cloth or metal, preferably metal, on two rollers, one near each end of the rod. Two types of ribbon are used, depending on the nature of the work to be done. In both types, the ribbon is graduated exactly like the face of the rod, except that, for the first type, the numbering runs both ways from zero and, in the second type, it runs in only one direction from zero. When a ribbon is not in place on the rod it is coiled on a reel or in a circular box provided for the purpose.

When in use on the rod, either style of tape ribbon is held, at its zero point, by its tape clamp, by means of which it is moved lengthwise of the rod, over the rollers, and along the shallow depressions or runways made for it in each side of the rod. This clamp runs in the same guides as the face target. In addition to the clamping device, it is provided with a vernier moving over the face graduations of the rod. Like the face target vernier, this reads to thousandths of a foot, and its zero corresponds in elevation to that of the zero mark on the tape ribbon. The working face of the tape ribbon is on the left side of the rod and, on the right side, are suitable devices for fastening its two ends together and for keeping it taut over the rollers.

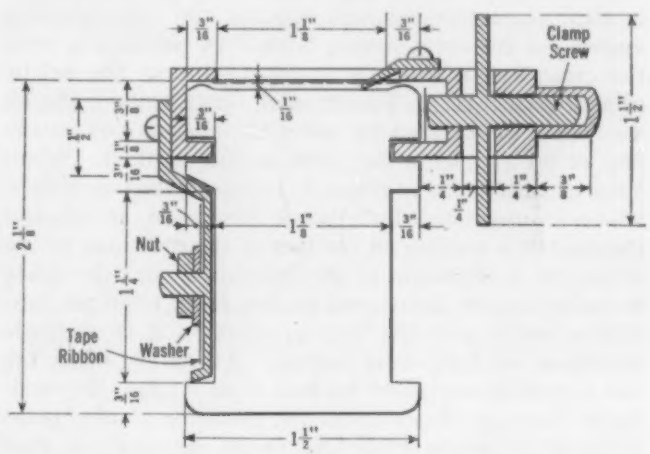


Fig. 2. Cross Section of the Rod and Ribbon Clamp

When the face target is not in use, it is clamped at the extreme upper end of the rod, and when the tape ribbon clamp is not needed it can be fastened at the lower end of the rod. Thus, in practice, the face target

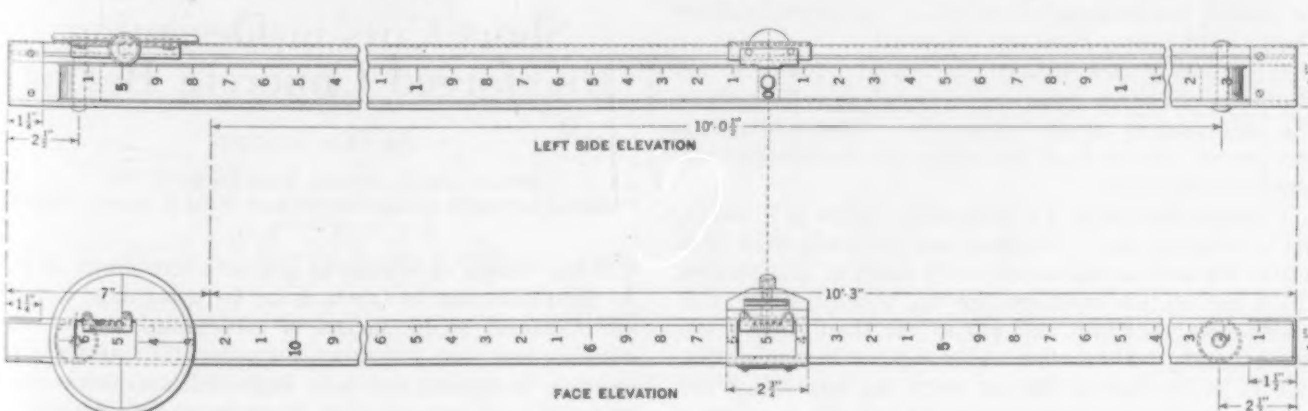


Fig. 1. A Universal Leveling Rod

and the tape ribbon clamp do not interfere with each other.

The two rollers are placed a few inches more than 10 ft. apart so that, with the face target clamped at the upper end of the rod, the tape ribbon clamp can move over a full 10 ft. If thought preferable, the clamp screw and its saddle can be placed on the tape clamp at the left side of the rod, between the point of attachment of the clamps to the tape ribbon and the clamp vernier, instead of at the right side of the clamp, as it is shown in Figs. 1 and 2.

In order to lighten the rod as much as possible, it can be largely hollow. If the rod is made of one piece, the hollow portion may extend to the back of the rod, or it may be confined to the $1^1/_4$ by $1^1/_8$-in. core if the rod is made in two or more parts.

STAKING OUT EARTHWORK

This rod is very useful in staking out earthwork. From the location center line profile and level notes, the elevation of grade and ground surface at each station is already known, and these elevations are entered in their respective columns opposite the corresponding stations in the cross-section book. In proceeding with the cross-section work, it is assumed that the height of instrument (HI) is known at all times, since it can be accurately determined by using the graduations on the face of the rod, as in the usual leveling method. When these elevations are known and the zero of the tape ribbon which is numbered both ways from zero, is set and clamped at a reading on the face of the rod equal to the difference in elevation of the instrument and the grade elevation at any given cross section, then, when the tape ribbon reads zero, the bottom of the rod is at grade elevation for that cross section. Therefore, when the rod is held at any point on that cross section, the reading of the tape ribbon gives the elevation of that point above or below the grade line, as the case may be, that is, the cut or fill (+ or −) at that point.

Thus, the cut or fill at various points along a cross section, including the slope stake points, are obtained directly from the tape ribbon readings, and are entered in the cross-section notes under the corresponding distances of these points from the center line. When the rod is held at the center stake of any given cross section and the tape ribbon is set for that cross section, as just described, the reading on the tape will verify or correct the location elevation of the ground surface there, furnishing a check on the work.

If a cross section is partly in cut and partly in fill, the point of change from one to the other will be where the tape reading of the rod is zero. Grade points on the center line and at the edges of the roadbed are similarly obtained.

Consider two cases: (1) a fill cross section in which the HI is below the grade elevation and yet is less than 10 ft. above the ground surface at every point in that section; (2) a cut section in which the HI is more than 10 ft. above the grade line, and yet is less than 10 ft. above the natural ground surface at every point in that section. Set off on the face of the rod (with the tape clamp vernier) the difference between the HI and the elevation of the natural ground at the center line and add or subtract at the center cut to the tape reading, as the case may be.

PROFILE LEVELING ELEVATIONS OBTAINED DIRECTLY

In running profiles, the tape ribbon with numbering running in one direction only from zero, should be used. As in the case of the tape used for running cross sections, this style of tape ribbon is attached to its clamp at the zero point. After the instrument has been set up, a reading is taken on the face of the rod, which is held on the starting-off bench mark.

For example, suppose that this reading is to be by target and is 2.403 ft. Assuming the elevation of the bench to be 463.285 ft., add the rod reading to the unit and decimal figures of the bench elevation. Thus, $3.285 + 2.403 = 5.688$. Move the tape ribbon clamp along the face of the rod until its vernier gives this reading (5.688) and clamp it there. This operation brings the number 3.285 on the tape ribbon on the line of sight. Then the reading on the tape ribbon, at any other point at which the rod is held, gives the elevation of that point by prefixing 46. In the same way, the elevation of all points desired within reach of this set-up of the instrument, can be obtained directly.

Where extreme accuracy is not desired, the elevation of a turning point is obtained in the same way. If more accuracy is needed, however, it may be had by using the face target. Suppose this reading to be 4.026. This number subtracted from 5.688 gives 1.662, and, on prefixing 46, the elevation of the turning point is found to be 461.662 ft.

In starting away from the turning point, after resetting the instrument, repeat the operations that were used in starting from the bench mark. In starting from either bench or turning point, when less accuracy meets the requirements of the work, the tape ribbon may simply be moved up or down until the line of sight of the instrument coincides with the graduation mark on the tape, corresponding with the unit and decimal figures in the elevation of the bench or turning point.

With its vernier target, the face graduation of the rod furnishes a leveling rod of the usual type that can be used in the ordinary way.

Short Cuts in Designing Reinforced Concrete Beams

By ODD ALBERT

STRUCTURAL ENGINEER, EAST ORANGE, N.J.
FORMER PROFESSOR IN MATHEMATICS AT WEST COLLEGE, SWEDEN

IN the design of reinforced concrete structures, many short cuts may be taken, either by using more simplified formulas or by means of tables and charts. In working out the following formulas the strength of concrete in tension has been neglected, and it has been assumed that the variation of stress to deformation of concrete in compression is a straight line.

RECTANGULAR BEAMS BY SLIDE RULE AND CHART

The following formulas may be found in any textbook and in standard specifications:

$$f_s = \frac{M_1}{A_s j d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

$$f_c = \frac{2\,M_1}{j\,k\,b\,d^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

$$k = \frac{n\,f_c}{n\,f_c + f_s} = \frac{1}{1+m} \quad . \quad . \quad . \quad . \quad . \quad [3]$$

$$j = 1 - \frac{k}{3} = \frac{3\,m+2}{3(1+m)} \quad . \quad . \quad . \quad . \quad [4]$$

where A_s = steel area in square inches
b = width of beam in inches
d = depth of beam to center of steel
E_c = modulus of elasticity of concrete
E_s = modulus of elasticity of steel
f_c = compressive unit stress in concrete
f_s = tensile unit stress in steel
j = ratio of arm of resisting couple to depth d
k = ratio of neutral axis to depth d
$m = \frac{f_s}{nf_c}$
M = bending moment in foot-pounds
M_1 = bending moment in inch-pounds
$n = \frac{E_s}{E_c}$

By changing the bending moment to foot-pounds, Equation 2 may be written, $d^2 = \frac{24\,M}{f_c\,j\,k\,b}$, and by using Equations 3 and 4, the following expression is obtained:

$$j\,k = \frac{2+3\,m}{3(1+m)^2}$$

Hence,
$$d^2 = \frac{72\,M\,(1+m)^2}{f_c\,(2+3\,m)\,b}$$

and the general formula for the effective depth is:

$$d = K_1 \sqrt{\frac{M}{b}} \quad . \quad . \quad . \quad . \quad [5]$$

Equation 1 may be changed into

$$A_s = \frac{M}{K_2\,d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

where $K_1 = (1+m)\sqrt{\frac{72}{f_c\,(2+3\,m)}}$, and

$$K_2 = \frac{j\,f_s}{12}$$

The values of K_1 and K_2, for various steel and concrete stresses, are shown in Table I.

Table I. Values of K_1, K_2, and K_3 (n = 15)

Concrete Stress	f_s = 16,000 K_1	K_2	K_3	f_s = 18,000 K_1	K_2	K_3
600	0.355	1,173	0.103	0.367	1,334	0.106
650	0.334	1,165	0.096	0.345	1,325	0.099
700	0.315	1,157	0.091	0.326	1,317	0.094
750	0.300	1,150	0.086	0.309	1,300	0.089
800	0.286	1,143	0.083	0.294	1,302	0.085
850	0.273	1,136	0.079	0.281	1,295	0.081

SOLVING BY SLIDE RULE

It will be noted that, from Formula 5, the required depth of a beam may be obtained by only one movement of the runner of the slide rule. For example, consider a beam 16 in. wide, taking a moment of 140,000 ft-lb. The problem is to find the minimum depth required if

$$n = 15$$
$$f_s = 18{,}000$$
$$\text{and } f_c = 750$$

Using Formula 5,

$$d = 0.309\sqrt{\frac{140{,}000}{16}} = 28.9$$

For a moment of 140,000, start on the A Scale of the

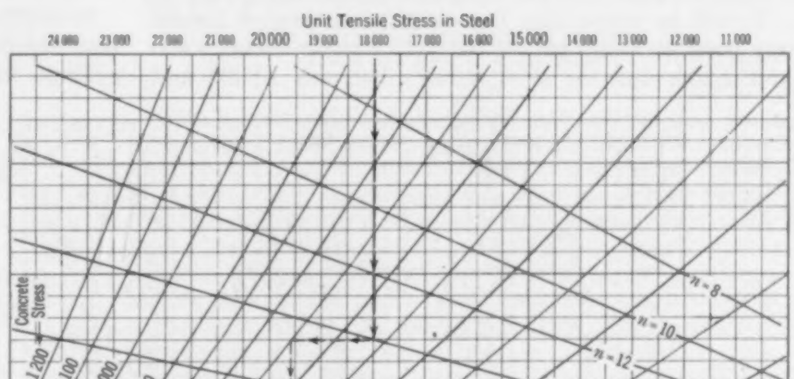


Fig. 1. Design Chart for Rectangular, Reinforced-Concrete Beams

slide rule. As it is an even number of figures, use the right-hand scale, putting the line on the glass over 14. On the B Scale use the right-hand scale also (16 has an even number of figures), and move the runner so that 16 will come under the glass-line. Then move the runner to 309 on the C Scale and read the numeral 28.9 on the D Scale as the required depth.

The area of the steel is expressed by the following equation:

$$A_s = \frac{140{,}000}{1{,}309 \times 28.9} = 3.70 \text{ sq. in.}$$

SOLVING BY CHART

By the use of the chart, Fig. 1, the minimum depth may be determined directly. The solution of Example 1 is shown by the dotted lines, which indicate the method of using the chart. To solve, enter the diagram at the top, for $f_s = 18{,}000$; turn horizontally at $n = 15$; turn down at $f_c = 750$; and read $K_1 = 0.309$. Then turn horizontally at $M = 140{,}000$; turn down at a width of 16 in., and read the effective depth as 28.9 in., which checks with the previous slide-rule calculation.

It will be noted that the chart takes care of almost any possible condition, for concrete stresses between 400 and 1,200, and for steel stresses between 10,000 and 25,000, with various values of n. The chart can also be worked in reverse to find either stresses, moment, value of n, or width.

DESIGNING CONCRETE SLABS BY DIAGRAM

In the design of concrete slabs, Formulas 5 and 6 may be used. However, Formula 5 can be further simplified by using a design width of 12 in. The following formula is then derived.

$$d = K_3 \sqrt{M} \quad \ldots\ldots \quad [7]$$

The required steel area is obtained by using Formula 6, and is $A_s = \dfrac{M}{K_2 d}$.

It will be remembered that M is the moment in foot-pounds, and that K_3 is equal to $K_1 \sqrt{1/12}$, and can be found in Table I. The diagram in Fig. 2 gives a very complete slab design for various conditions, where

$f_s = 18{,}000$ lb. per sq. in.
$j = 0.867$
and $n = 15$

It will be noted that no computation is required and that the diagram has a very wide range. The following example indicates how the chart is to be used.

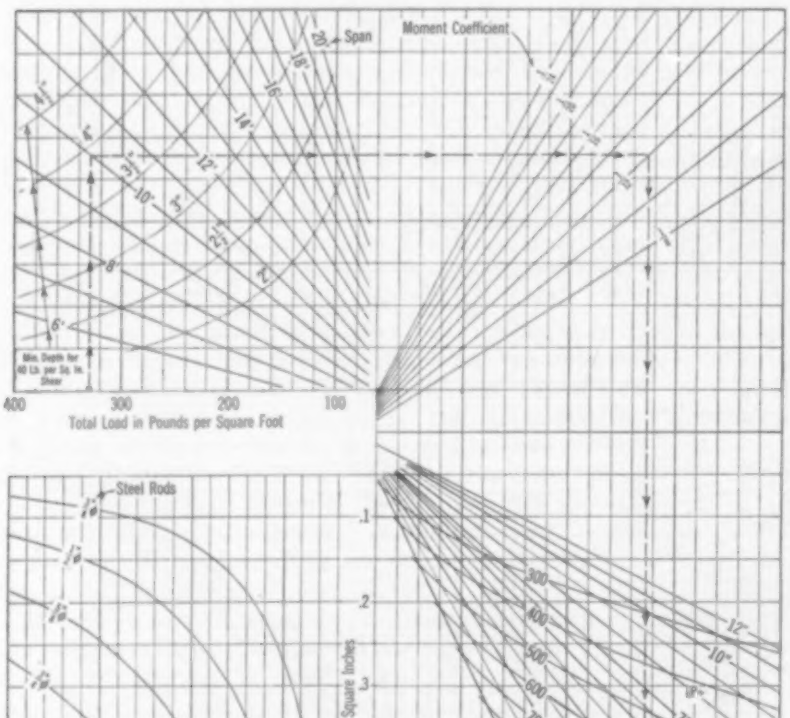


FIG. 2. DIAGRAM FOR REINFORCED CONCRETE SLABS

A PRACTICAL EXAMPLE OF THE USE OF CHART 2

Considering a 10-ft. continuous slab, carrying a live load of 240 lb. per sq. ft.—the concrete stress cannot exceed 600 and the steel stress is assumed to be 18,000. If the dead load is assumed to be 90 lb., the total load will be 330 lb. per sq. ft.

After entering the diagram at 330, turn right at a span of 10 ft.; read the minimum depth for shear of 40 lb. per sq. in. which is 3.9 in.; turn down at 1/12 for the continuous beam moment coefficient; turn left at a depth of 6 in., reading $f_c = 550$, $M = 2{,}750$ ft-lb., and $A_s = 0.35$; turn down at 5/8 in. rods and read the spacing to be $10^1/_2$ in. A 6-in. slab will have a maximum shear of $\dfrac{3.9}{6} \times 40 = 26$ lb. per sq. in.

If computed, the following values may be obtained for the minimum depth:

$$d = 0.106\sqrt{2{,}750} = 5.56 \text{ in.}$$

$$A_s = \frac{2{,}750}{1{,}334 + 6} = 0.393$$

It will be noted that a value of 0.867 has been used for j. This corresponds to an allowable unit stress in concrete of 800 lb. per sq. in. For smaller values of f_c, the chart is on the safe side.

Other uses of this diagram will suggest themselves to the designer working with continuous slabs.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

The Hangchow Sea Wall

SIR: One of the great river works of the ancient Chinese, not mentioned by Mr. Lane in the December number, is the Hangchow Sea Wall, probably the longest continuous sea defense in existence. It has a total length of approximately 125 miles, divided about equally along the north and the south sides of Hangchow Bay. Owing to the vagaries of river and ocean currents, little of the south section is serving a useful purpose, great areas of alluvial lands having been built up between the wall and the sea. On the north shore, however, the wall is still a vital factor in the lives of the people. The general location of the wall is shown in Fig. 1, while a typical cross section is given in Fig. 2.

The photograph shows the sea wall at Haining just before the arrival of the bore. Curved recesses for junk refuges are provided to reduce the shock of the main wave. As the bore approaches, the owners of the junk come out and fend it off from the wall with poles. Boats of this size do not attempt to ride into the river with the main wave of the bore but, with the following waves, great fleets of them may be seen coming up the river with the rushing current.

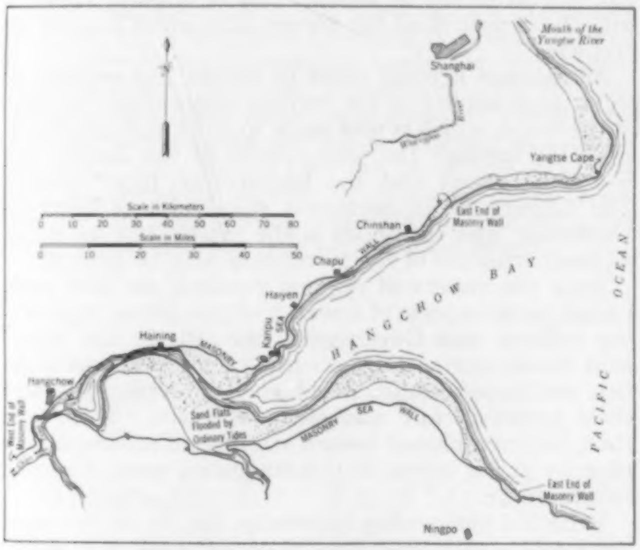


FIG. 1. THE HANGCHOW SEA WALL
Chekiang Province, China

The heavy tides on the Asiatic coast of the Pacific are accentuated in Hangchow Bay, this being due partially to the funnel-shaped entrance and also to the peculiar disposition of the sand bars at the entrance. The initial wave of the incoming tide has a frontal height of 5 or 6 ft., which is followed closely by another of nearly equal height and an ordinary total rise, in a very brief period, of about 15 ft., with an occasional increase of over 20 ft. The characteristics of the bore vary at different localities and, to some extent, with wind velocity and direction. Whether it be by frontal attack of waves or high-velocity along-shore currents, the effect on a shore composed of alluvial deposits would be disastrous without some artificial protection.

While accretion is going on in some sections, there are others which have been washed away for great distances. For instance, in the vicinity of Hayen, which is about 50 miles east of Hangchow, the shore has, within historic times, receded for a distance of 12 miles.

THE HANGCHOW SEA WALL AT HAINING
Before the Arrival of the Bore

The history of the conception, promotion, and construction of this great sea wall would make reassuring reading for those members of the engineering profession who have struggled through long years of effort to secure the financial backing necessary for an enterprise which they felt was for the public good. For hundreds of years, the rich farming lands of the alluvial plains had been devastated by high storm tides; and when earthen dikes were constructed, they were frequently destroyed either by storms or by the strong currents of the bore. The first masonry wall was built by Ch'ien Liu in 910, although additions and repairs have been made at various times up to the present.

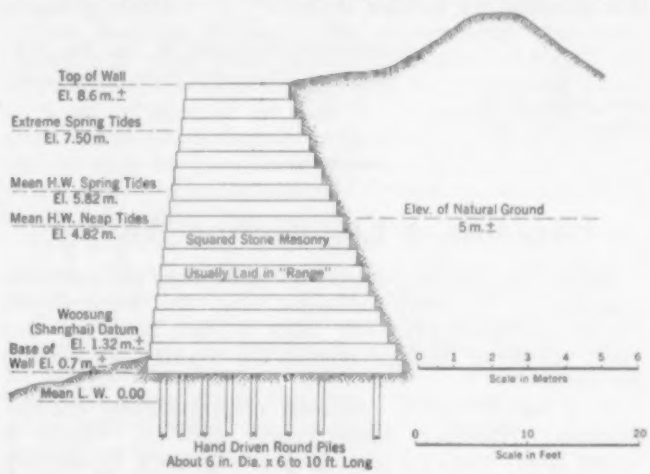


FIG. 2. APPROXIMATELY TYPICAL SECTION OF THE HANGCHOW SEA WALL

ARTHUR M. SHAW, M. Am. Soc. C.E.
Consulting Engineer, National Consulting Commission, Republic of China

Hangchow, China
March 1, 1931

Fig. 2. Diagram for Reinforced Concrete Slabs

The Flood Control Problem

To the Editor: After reading Mr. Coleman's article, in the February issue, I feel that the essence of a rational solution of the Mississippi River problem seems to rest on the following facts: (1) The present channel past New Orleans is incapable of discharging safely more than about 1,250,000 sec-ft., while a flood of 3,000,000 sec-ft. may be anticipated. (2) A judicious rectification of the channel between the mouth of the Red River and Cairo will enable that channel to carry all the water that has yet been contributed to it at any one time, so far as existing records show, thus rendering diversions above the first mentioned point unnecessary. (3) To carry the water which may be brought to the mouth of the Red River, the discharging capacity of the river below that point must be increased either by rectification and enlargement or by the provision of an auxiliary channel to carry part of the water—or possibly by both expedients.

Since the diversion of water through the Red River to the Atchafalaya causes the formation of a bar at the mouth of the Red River, which is seriously obstructive to navigation, a point of diversion should be selected farther down the river, where much greater depths exist and where the formation of such a bar would require a much longer time.

As a proper, though not necessarily the only, location for such a diversion, Mr. Coleman has suggested the termination of the straight reach below Baton Rouge, where the distance to the Gulf of Mexico, in a straight line, is about fifty miles. The present mouth of the river is over two hundred miles distant by way of a very crooked channel.

A diversion at this suggested point has the advantage of continuing the flow in a straight line, thus tending to minimize the deposition of silt in the present channel below the diversion. Whether such a diversion channel should be permitted to become the main channel of the river or should be restricted to the discharge of flood water in excess of 1,500,000 sec-ft., which is the amount that can be handled through the Bonnet Carré Spillway, is a question for further study.

Gardner S. Williams, M. Am. Soc. C.E.
Member, Mississippi River Commission

Ann Arbor, Mich.
February 12, 1931

Bargains in Engineering Ability

Dear Sir: Nothing angers me more than to hear some complacent executive intimate that the unemployed are all incompetent. The facts do not bear out this view. Some of the best men in the country are looking for work.

As a member of a volunteer committee for the Engineering Societies Employment Service, which is trying to get work for unemployed engineers, I naturally meet all kinds of men and hear many sides of the employment question. Two recent interviews brought home to me the true conditions.

An executive of one of our large railroads will soon need the services of several junior engineers. I went to him hoping to place some of our men. He greeted me with a statement to the effect that "engineers who are unemployed today are incompetent drifters." This started an argument and he eventually agreed to give our men a chance.

Take another instance—a high ranking retired Government officer is in charge of a municipal department that employs many engineers. His attitude was diametrically opposite to that just quoted; he said, "I am sorry that I can't put on any engineers now. The truth is that I actually need several, but there are 17 men on my payroll who don't fit and I am keeping them because I know that they could get nothing today if I let them out."

This shows accurately the present situation. Smug incompetents are holding good jobs because their employers will not throw them out to starve, while some of the best engineering brains of the country are for sale cheap. Today is bargain day for men. Right now it is possible to take your pick and find just the men your organization will need in the near future. Tomorrow may be too late.

Edward W. Ritchie, M. Am. Soc. C.E.

New York, N.Y.
February 27, 1931

A Great Research Service

To the Editor: In directing attention to the value of research in advancing civil engineering, Dr. Flinn, in the October issue, begins his interesting and timely paper with an important question. He asks, "How can all existing knowledge that should be utilized on a given project be quickly put into the hands of the man on the job, so that he can be assured that he is doing his work with the benefit of all the known facts which bear on his problem?"

An attempt is being made to answer this question in so far as it applies to the current engineering literature of the world, which is now made quickly and completely available through the joint efforts of the Engineering Societies Library and the Engineering Index Service. The Library is an organized storehouse of technical knowledge, and the Index is the master key by which all compartments of the storehouse may be entered.

Since the results of original research are first made known in the reports of research organizations, engineering colleges, and Government bureaus, in the papers read before engineering, scientific and, technical societies, and in periodicals, it is highly important to gather these systematically and to index them. Much will, then, be accomplished toward utilizing all existing knowledge by giving access to this staggering mass of current information.

Recorded engineering knowledge has, in recent years, increased to such an enormous extent that it is practically hopeless for anengineer to attempt to maintain a complete private library on any subject, no matter how specialized it may be. In contrast to the 100 publications reviewed in the preparation of the first volume of the Engineering Index, there are today more than 2,000 publications in 20 languages, devoted to the engineering achievements and the industrial progress of modern civilization. Each year brief descriptive index items are prepared by a staff of engineers and linguists for over 50,000 articles, papers, and reports. The Index items are then classified into 223 specialized divisions covering all branches of engineering, all leading industries, and all important processes.

Maximum flexibility, utility, and promptness are obtained by publishing the Index on cards, which are distributed daily and weekly. Since all the publications received are permanently filed in the Engineering

Societies Library, copies of any articles or papers indexed may be procured through the photoprint service of the Library. In fact, many societies and publishers are now listing selected items from the Index in their periodicals, as is Civil Engineering.

In January 1928, the Engineering Index was reorganized for this larger undertaking of preparing a complete descriptive card index. The Engineering Societies Library has also undertaken the enormous task of compiling a master index to all past literature. When this is completed and is kept continually up to date by the Engineering Index Service, the question raised by Dr. Flinn will be more nearly answered then ever before.

While the Engineering Index Service, at the present time, covers essentially current literature, it also includes each year several hundred reviews of important new books prepared by the Library. It could, therefore, be readily expanded to include all new books as well as periodical literature. An inclusive accumulative index would become a complete guide to all existing engineering knowledge, the need for which is so convincingly set forth by Dr. Flinn. If there were the necessary funds and evidence of a sufficient demand, the facilities of the Engineering Societies Library and the present procedure of the Engineering Index Service could be easily adapted to this larger undertaking. Research agencies and individuals can greatly assist others engaged in similar investigations, as Dr. Flinn suggests, by depositing the results of their work in libraries. Any material in manuscript form that is received by the Engineering Societies Library will be indexed by the Service.

After carefully studying the situation, the Committee on a Clearing House for Engineering Societies Research of the Engineering Foundation made the encouraging recommendation that the Foundation "use its best endeavors to aid the Engineering Societies Library and the Engineering Index Service in securing and maintaining an index service that will be of real service to those interested in engineering research." The assistance of the Engineering Foundation in gathering the results of isolated research will be most helpful.

J. E. Hannum
Editor, The Engineering Index Service

New York, N.Y.
February 25, 1931

Arguments for "Yield Strength"

Sir: The subject discussed by Professor Moore, in the December Civil Engineering, is interesting to engineers who are either working on strength of materials or are using such data in design. Any work which helps to clarify our idea on what such definitions mean is valuable.

As regards the unlikelihood of the existence of a definite elastic limit, it is helpful to have such a statement as Professor Moore's. These are essentially the conclusions forced on Mr. McVetty of these laboratories, by virtue of the results he has obtained from tests at high temperature. We have the recent work of Kimball on internal friction of metals which seems to indicate that these laws apply even to the origin. Furthermore, Sayre's work on hysteresis shows definite looping for small stress. There seems to be considerable ground for believing that no definite elastic limit exists. These and other facts make it very desirable that some general term such as "yield strength" be adopted for use in design.

For all cases of static loading or its equivalent, the yield strength, where strength characteristics alone are being considered, and for all other cases the endurance limit for the particular type of stress encountered, would form the basis of design. This idea has been already mentioned in the paper "Factor of Safety and Working Stresses" by C. R. Soderberg, in the *Transactions* of the Applied Mechanics Division, American Society of Mechanical Engineers, 1930. The adoption of the term "yield strength" would simplify the work of building up additional data on the choice of working stresses, a field to which more attention will have to be given in the future.

John M. Lessells
Manager, Mechanical Division Westinghouse Electrical and Manufacturing Company

Pittsburgh, Pa.
February 14, 1931

Practical Definitions Needed

Dear Editor: In his article, in the December issue, Professor Moore refers to three ways of determining elastic strength. The Sub-Committee on Elastic Strength of the American Society for Testing Materials has had this question under active discussion for more than a year and has formulated two proposals, referred to as Proposal A and Proposal B.

In Proposal A, the practical or significant measure of elastic strength is called the "yield strength" of the material, and is defined as the stress at which a material exhibits a specified limiting permanent set.

In Proposal B, the significant elastic strength property of the material is called "yield point," and is defined exactly as yield strength is defined above. In other words, in Proposal B yield point has been redefined, the present definition being "the stress in a material at which there occurs a marked increase in strain without an increase in stress."

The method proposed for determining the yield strength or yield point is that illustrated in Fig. 1 (*c*) of Professor Moore's article—that is, a specified value of a set is selected so that it determines a value of stress below which damage to the material due to inelastic action may be considered to be negligible and above which appreciable damage would occur. This method is referred to as the "set method."

For material that exhibits, at a certain stress, the special characteristic of yielding without increase of stress, the drop-of-the-beam method is proposed.

Further, for tests to determine the acceptance or rejection of material whose stress-strain characteristics are well known from previous tests of similar material in which stress-strain diagrams were plotted, the total strain corresponding to the stress at which the specific permanent set occurs will be known within satisfactory limits; therefore, in such tests a specified total strain may be used, and the stress on the specimen when this total strain is reached is the value of the yield strength or yield point. The total strain can be obtained satisfactorily by use of an extensometer or, in some cases, by use of dividers, particularly if the surface of the specimen is prepared so that the line made by the dividers is a fine line, and if it is observed through a reading glass. But it is recommended that this approximate method be used only after agreement between producer and con-

sumer, with the understanding that check tests be made for obtaining stress-strain diagrams for use with the set method to settle any misunderstandings.

With the increasing use of new materials and of new uses for old materials, the need for a practical definition and method of determination of the elastic strength property for a material are becoming more and more important. Professor Moore's article is very timely and helpful in calling attention to the factors involved.

F. B. SEELY
Professor of Theoretical and Applied Mechanics, University of Illinois

Urbana, Ill.
February 22, 1931

New Mississippi River Considerations

TO THE EDITOR: The article by Mr. Coleman, in the February issue, very ably presents the different points of view on flood control of the Mississippi and gives pertinent and interesting data along a line that has long been of great interest to me. I refer particularly to the silting of the channel below an outlet, as that indicates the real problem of transportation of detritus. This will probably be taken up in due time, as the present plan is carried out. Although complete data for laying down a final plan were originally lacking, the Army engineers had the courage to start a plan that has been approved by Congress and the President. Since they have displayed this initiative, they will probably leave no stone unturned to develop the present plan in a way that will give the Mississippi Valley practical protection.

Detritus passing down the river has caused much of the present difficulty and is responsible for most of the failures of well laid hydraulic plans for river control. I am very nearly convinced that detritus causes the caving banks and has forced the river to form its great bends. Otherwise, how could this great amount of material have been distributed so uniformly as to build the vast domain from Cairo to the Gulf? Statistics indicate that over half of the detritus entering the valley does not pass out at the mouth of the river. It must, then, be admitted that the material is deposited either in the river bed or in the overbank—between the levees—where it is constantly reducing either the channel or storage space. It is pretty generally recognized that diversions must be relied on below the mouth of the Arkansas, but their capacity and the effect of silting are in dispute.

It is my hope that no changes will be made in the present plan except for the purpose of showing a definite lowering of the flood plane, south of Cairo, of at least 10 or 15 ft. The plan for doing this that appeals to me most is that of utilizing the Atchafalaya to by-pass as much as 3,000,000 sec-ft.—only if it is necessary—the short way to the Gulf. The inlet of this channel should be controlled, so as to withdraw, if possible, the major portion of the detritus passing down the Mississippi at this point. The channel should be in operation only when river stages south of Old River begin to be dangerous. Recent experience indicates that a guide channel from a location, such as Krotz Springs, to a point well west of Morgan City should, when subjected to sufficient discharge, readily enlarge with very little shifting or formation of bends. Since this channel is a shorter route to the Gulf by 125 or 150 miles, it should produce a definite lowering of the main channel at Old River, and for some distances above and below it. The passing of this lowering upstream can probably be accomplished by a judicious distribution of cut-offs. Perhaps the hydraulic laboratory could give some indication of what lowering to expect, if this plan were tried.

The objection to leaving this channel open permanently and letting the Mississippi go entirely by way of the Atchafalaya is that it would upset the slope for several hundred miles upstream, perhaps causing destructive caving that could not be controlled. Except in a few locations, I do not, at present, believe much good can be accomplished with cut-offs, especially if the Atchafalaya outlet should be put in operation. These localities, which are widely scattered, are, in general, below the mouths of the Arkansas and Yazoo rivers. Cut-offs for Giles Bend and the bend at New Madrid appear advisable, according to the map, although a study of the slopes of both high and low waters through these stretches might indicate otherwise.

All of these factors are complicated by the detritus problem, so it is impossible to decide upon the practicability of methods without preliminary tests in a hydraulic laboratory and a final test on the river itself. I hope that those entrusted with the carrying out of the plan will attack it aggressively, for by no other method can they hope to obtain worthwhile results.

W. E. ELAM, M. AM. SOC. C.E.
Mississippi Levee Board

Greenville, Miss.
February 11, 1931

Handicaps to Highway Transport

DEAR SIR: Generally speaking, Mr. Halsey has covered very well the problems of highway transport in his paper, in the December number. I cannot overemphasize the necessity for adequate terminal facilities which he mentioned under "Special Provision for Commercial Vehicles." To my mind, this is one of the most serious problems today hampering the fullest development of automotive expansion, for highway transport. Excellent progress has been made in the development of trucks and buses. Remarkable improvements have been carried out, in so far as the highways on which these trucks must operate are concerned, but little has been done to provide suitable terminal facilities for motor vehicles in general, an essential part of the program of highway transport development. Conditions today are similar to those which would exist if a splendid system of railroads had no depots.

Parking and loading are, without question, the most difficult problems of traffic control, and there is no alternative but the provision of suitable off-street facilities. To hamper the movement of traffic flow by parking and loading in streets which are already inadequate, is to my mind a most uneconomical procedure. The fundamental of good accessibility for property development is well established, yet there seems almost a deliberate attempt to ruin this accessibility by jamming the streets with parked vehicles. In a few years, the parking problem should be entirely overcome by the provision of suitable off-street terminal facilities.

Some of the more important factors which have developed commercial traffic upon an economic basis have been pointed out by Mr. Halsey. There is, however, the much mooted question of proper taxation and license fees. Comment on the unfair use of public highways for transport by large buses and trucks arises from the inequality in taxation for the financing of highway developments. On the one hand, we have a system of transportation

which must provide its own rights of way, and channels and pay for them entirely out of its own earning; on the other, a more or less paralleling, yet complementary, system of transportation, which uses public thoroughfares paid for by public funds. The inequality which certainly existed in the past is disappearing gradually by new regulations as to the licensing of commercial carriers and the gasoline tax. Taxation for public improvements has always been a debatable subject, but I think it is generally conceded that the gasoline tax is as fair a tax as any; and while government always lags behind business and economic development, it nearly always arrives at some degree of fairness in the distribution of public costs.

Theodore M. Matson
Assistant Traffic Engineer
Department of Public Safety

Philadelphia, Pa.
February 12, 1931

Reducing Highway Dangers

Sir: Mr. Halsey's discussion of certain highway problems, in the December issue, is enlightening. The term "highway transport" has been in use for a number of years but apparently little attempt has been made to define it. At present, the terms "highway transport," "highway transportation," and even "highway traffic" appear to be used more or less interchangeably, and certainly the last two include all movements over the highways. It might clarify the situation considerably if the use of the term "highway transport" should be restricted to cover truck and bus operation only, as suggested by Mr. Halsey.

In discussing three-lane highways, he says nothing about the element of danger due to the impossibility of controlling movements upon the middle lane. Some observations appear to indicate that where the traffic movement is predominantly in one direction in the morning, and in the opposite direction in the afternoon, the number of accidents is reduced by changing the road from a two-lane to a three-lane width, but other investigations seem to indicate that a three-lane highway is more dangerous under practically all conditions. It is evident that a great deal of study of accident records upon two- and three-lane highways, under similar conditions, is amply warranted by the expenditures and accidents involved. The addition of a third lane to a two-lane highway costs a great deal of money and the engineer should be able to know, not guess, what will be the resulting effect upon both congestion and accidents under given conditions.

It is very interesting to note the author's statement that traffic-actuated signals are used exclusively by the Massachusetts Department of Public Works. Certainly the fixed-cycle signal at comparatively light traffic intersections is one of the most inefficient devices used in connection with modern highways. Although of great value when handling heavy traffic, such signals neither relieve congestion nor reduce accidents when used at light-traffic intersections, according to the meager data available covering actual accident records.

R. L. Morrison, M. Am. Soc. C.E.
Professor of Highway Engineering and Highway Transport,
University of Michigan

Ann Arbor, Mich.
February 16, 1931

Growing Need for Good Highways

Sir: The paper on "Highway Transport Problems" by Mr. Halsey, in the December issue, has proved to be very stimulating. As one professionally interested in the control of traffic, it has long been my opinion that a very large part of our problem of regulation is the result of highway design which follows classical methods and takes little consideration of the actual characteristics of current traffic movement.

This conclusion is clearly supported in Mr. Halsey's discussion of the alignment of traffic obtained through the type of highway construction used. Before the implications of modern automotive traffic were fully understood, there was ample excuse for laying down highways that did not fit the needs of the traffic which subsequently developed. This excuse no longer exists, for traffic flow characteristics are now quite stabilized and well understood. Aside from a trend toward higher speeds and larger and heavier units, no great change is to be expected within the next few decades.

Despite this situation, it is regrettable to observe, in practically all parts of the country, numerous examples of new construction in both streets and highways which will only serve to increase the accident and congestion hazard, which has become so important a problem. For trunk lines and important routes, we have certainly passed the point where there is any special merit in the fact that a roadway is hard, smooth, and wide. These characteristics ought to be assumed. The real question is whether or not the details of design and construction are such as to accurately suit the roadway to the traffic which is to use it.

Thus, recently in a Western city I saw a roadway, approximately 200 ft. in width, surfaced with beautifully smooth pavement. It was part of what was significantly called "the great highway." Traffic will never be able to use this roadway to capacity, nor indeed to operate over it in any volume, without utter confusion, unless it is provided with expensive control apparatus, which will at best be less effective than the elements which should have been incorporated in the original construction.

An observation of the traffic control problems on the major highway systems of the country leads to the conclusion that there are these three major problems, which can, and eventually must, be solved by highway designers: (1) the accurate alignment and segregation of fast and slow traffic moving in the same direction; (2) the positive physical separation of traffic streams moving in opposite directions; (3) the design of intersections with an operating capacity equivalent to that of the tributary routes and with provision for the elimination of the more critical conflicts which now result in delays and hazards.

These achievements are not visionary for, as Mr. Halsey points out, there are numerous examples of actual accomplishment. Unfortunately, many of the more progressive designers are handicapped by bureaucratic traditions or by fiscal considerations. They have a right to demand that they be permitted to build for present and future needs. In the long run, such practice will prove the more economical. At any rate, it is the only solution which we have for our growing problem of congestion and accidents.

Miller McClintock
Erskine Foundation
Department of Government, Harvard University

Cambridge, Mass.
March 3, 1931

Rankine's Formula

DEAR SIR: In the article by Mr. Viterbo, in the January number, there appears to be an error in the statement of Rankine's formula for allowable pressure on soil at a given depth. The proper relationship between the maximum unit pressure, P, that may be obtained at a depth, d, in soil of density, p lb. per cu. ft., and angle of repose, ϕ, is expressed by the following equation:

$$P = dp \times \left(\frac{1 + \sin\phi}{1 - \sin\phi}\right)^2$$

which is not the same as the equation given by Mr. Viterbo, namely:

$$P = dp \times \frac{1 - \sin^2\phi}{(1 - \sin\ \phi)^2}$$

A complete derivation of the Rankine formula may be found in numerous texts. In Mr. Viterbo's table, the unit bearing values (given in parenthesis) at a depth of 4 ft. 0 in. in different types of soil are as follows:

Soil entirely immersed in water:

$\phi = 0°$ $P = 400 \times 1 =$ 400 lb. (400)

Average soil:

$\phi = 30°$ $P = 400 \times 9 =$ 3,600 lb. (2,000)

Good soil:

$\phi = 45°$ $P = 400 \times 34 =$ 13,600 lb. (7,000)

Very compact soil:

$\phi = 60°$ $P = 400 \times 194 =$ 77,600 lb. (39,000)

It will be seen that the formula given by Mr. Viterbo represents more conservative practice than Rankine's formula, and as the correctness of Rankine's theory is questioned by some authorities, the use of the one or the other formula may be open to discussion. However, Mr. Viterbo is not justified in calling his equation Rankine's formula.

CONSTANT R. MARKS, Jun. Am. Soc. C.E.
Bridge Designer, Atchison, Topeka and Santa Fe Railway Co.

Chicago, Ill.
February 23, 1931

The United Engineering Trustees, Inc.

DEAR SIR: On page 440 of the February issue of CIVIL ENGINEERING, the following statement is made:

"To refresh the memories of those who may be uncertain about the function of United Engineering Trustees, Inc., a few words of explanation may be in order. The corporation was formed May 11, 1904, to hold the legal title to certain real estate owned by the four Founder Societies, to hold trust funds given to these societies jointly, and to advance the engineering arts and sciences in all their branches."

I beg leave to say that this statement is not a correct one so far as the American Society of Civil Engineers is concerned. On March 2, 1904, a ballot of the entire membership was canvassed on the question as to whether the American Society of Civil Engineers should join with the other three societies of mining, mechanical, and electrical engineers in the acceptance of the proposed gift of Mr. Carnegie, which ballot resulted as follows:

In favor of acceptance 662
Not in favor 1,139

so that, by a vote of almost two to one, the Society, having its own society house, did not join the other three Founder Societies.

During the following 12 years, United Engineering Society had nothing to do with the holding of the real estate of, or acting in any capacity for, the American Society of Civil Engineers. By invitation of United Engineering Society, the American Society of Civil Engineers became one of the four Founder Societies on August 10, 1916.

CHARLES WARREN HUNT, M. Am. Soc. C.E.

New York, N.Y.
February 16, 1931

Water Purification Practices

DEAR SIR: The very interesting article by Mr. Wall, in the January issue, revives many recollections regarding the progress of water purification in the Middle West.

Filtration is as old and capricious as nature, but the brilliancy of a naturally filtered water, though deservedly enticing, is not in itself a controlling index of a suitable public water supply. Hidden within this colorless water are various minerals dissolved in its slow course through the earth, which may render it unsuitable for general use. However, man received inspiration from nature when he devised the slow sand filter and thus succeeded in filtering surface water, so long as filtration was confined to a rate which gave time for the necessary biological action to remove organic pollution from the water, as well as to clarify it.

The slow sand filter, while giving good results in operation, proved too slow, extensive, cumbersome, and expensive of construction and operation to suit the mechanical mind. The outcome is the present-day mechanical filter which is now designed and developed to such an extent as to merit consideration in any place where filtration is needed. It is the only kind of filter adapted to the conditions of the Middle West. But even here its success depends upon previous careful preparation of a turbid water and an after-filtration safeguard. Its usual high rate of filtration and the manipulation incident to its operation preclude its functioning biologically. It strains from the water the unsettled remnant of coagulated suspended matter, incidentally removing a large number of the bacteria, and can be made, through the aid of other processes, to produce a water of sparkling brilliancy fit for all domestic uses.

Sometimes the mechanical filter plant is designed to give a spectacular effect, thus combining the artistic with the useful. In spite of this, however, dependence for success upon its helpers—namely, the settling basin and the sterilizer—forbids ranking it, in itself, as the outstanding instrument of water purification. Like the moon, it shines in a reflected light.

The merit of the settling basin and its auxiliary processes, which render efficient filtration possible, has been very much obscured for many years by the unmerited claims made for the mechanical filter. It requires much more skill and study to prepare water for the filter in the settling basin than it requires to filter it. While studies have been made in the past and theories of the process of sedimentation advanced, it is only of comparatively late years that the phenomena of sedimentation have been correctly interpreted and the design of the settling basin has been improved radically.

The economic limit of plain sedimentation, the mixing of coagulants with the turbid raw water, the adaptation

of the kind of coagulants to the physical and chemical characteristics of the water, and the application of the proper coagulants in kind and amounts to suit the seasonal and other variations of the characteristics of the source of water supply, have all been studied and correlated more precisely than heretofore. Also, there is continued improvement in the control of the delivery of water into, its circulation through, and out of the settling basin, which is reflected in better design and more efficient and economical operation of the basin. This good work can reasonably be expected to continue. But even now the advance in the art of sedimentation is noteworthy, being exceeded only by that of sterilization of the water supply.

Chlorination is the outstanding achievement in water purification made during the past generation, for it affords the surest protection against water-borne diseases. Experience has shown that chlorination can make the effluent from an efficiently operated settling basin and lake water, polluted in a moderate degree, a reasonably safe water supply. Of the three important factors employed in water purification, filtration is the one that may be dispensed with in many cases without exposing the public to the danger of water-carried diseases. But it is unwise to attempt this, because of the public preference for tasteless water of sparkling clearness, which can be obtained by a judicious combination of these three important factors.

Wynkoop Kiersted, M. Am. Soc. C.E.
Consulting Engineer

Liberty, Mo.
March 3, 1931

Treatment of Water

To the Editor: In the December Civil Engineering, Mr. Weston has given a clear and comprehensive outline of the principles involved in the proper treatment of water for domestic consumption.

Re-oxidation of waters as by sprays and nozzles, to eliminate tastes and odors, tends at the same time to increase the oxygen saturation of the waters, sometimes to a point where they become quite activated. As a result, air-binding may be caused in filters to an excessive degree. Increased use of mechanical equipment for continuous removal of settled matter from sedimentation basins, as exemplified in the new treatment works at St. Louis, may be predicted with a reasonable degree of certainty for the same reason that actuates the use of such equipment in preliminary sedimentation basins and softening plants.

The use of dry chemical feeders with automatic proportioning devices is a great help, although too little attention has been paid to the matter of placing them as close to the point of application as can be arranged without long chemical lines, which have been an unending source of trouble. Dry feed machines have been used to feed and slake quick lime at the Wheeling, W.Va. plant, for more than five years.

While chemicals have been applied to raw water in the suction of pumps and in discharge lines, such practice has caused considerable trouble, especially with the use of softening chemicals. It is better to feed such chemicals directly into the mixing chamber. For the removal of precipitated matter, two or three hours would seem to suffice for Great Lakes waters and for many of the streams having their source in the mountain ranges in the East and West, but for highly polluted streams, such as the Ohio River, eight hours is not too much.

Filter plants of recent design are now being equipped with washing facilities to produce an expansion of 50 per cent or more, as developed by the experiments made in Detroit. Our practice is to install a brass or bronze screen between the sand and gravel in the filters as at the new West Side Filtration Plant in Erie, Pa., to prevent overturning of the gravel bed with the higher rates of wash, so often experienced even with the former rate of 24-in. rise per hour, although but very little has been said by engineers about this difficulty. Furthermore, it has been our practice to admit the wash water to a chamber formed by a false bottom and then to distribute it through bronze pipes extending through the false bottom on 6-in. centers, into which are screwed bronze strainers. This is in contrast to the ordinary pipe lateral system, the efficiency of which has been found to become impaired through the admission of sand, resulting in impaired washing and filtration.

In the past, sand as large as 0.70 mm. effective size has been advocated. Today many engineers specify large sand, probably as a result of the experiments made some years ago at Detroit. However, the local character of water and the efficacy and method of chemical treatment, having in mind the desired results, have a direct bearing on the size of sand. In Ohio, it is required that filters produce an effluent of satisfactory bacterial quality even before chlorination. In the elimination of odors and tastes it has been demonstrated that of the three methods tested—ammonia, sulfur dioxide, and activated carbon—the unit cost increases in the order named with practically equal results.

There still is too little cooperation between the designer and the chemist in the layout of the modern water-treatment works, but designing engineers cannot afford any longer to design stock plants to meet all conditions, as has been done by some in the past. The chemist, or "chemical engineer," is of great value to the good designer and his services are being used and appreciated more and more. Regardless of how much attention is given to the production of a water best suited for domestic consumption, much of the accomplishment at the purification plant may be negatived through the improper design, installation, and use of materials in distribution systems and in the piping system in the home, by virtue of which the water under certain conditions becomes so changed as to bring about condemnation of the water-treatment plant itself without due cause.

J. F. Laboon, M. Am. Soc. C.E.
Hydraulic and Sanitary Engineer
The J. N. Chester Engineers

Pittsburgh, Pa.
February 24, 1931

Establishing the Use of Chemicals

Editor: The excellent review of city water-supply development by Edward E. Wall, in the January issue of Civil Engineering, is a reminder of the long fight that sanitary engineers had to establish the practicability and safety of the use of chemicals, such as sulfate of alumina and iron, as coagulants. The antagonism was personally led by doctors, 50 per cent of whom, I believe it is a fair estimate to say, were allied against us. As a second line of attack the labor unions shouted against chemical filters, both demanding well or spring water, whether or not it was obtainable.

Today the medical fraternities claim credit for the great reduction in water-borne diseases. Furthermore, in this time of depression, the labor unions are the staunchest supporters of bond issues, with which to create water-treating plants.

One point should be brought out more clearly—today to build a plant that removes bacteria only is a rarity. In most cases there are supplementary parts that may remove iron manganese tastes or odors, but more frequently soften the water by some sort of attack on the hardening elements.

The new Howard Bend Plant at St. Louis should be credited with an additional function, in that it delivers into the other end of the distributing system opposite to that in which the previous or existing supply is delivered, thus vastly reducing future costs of carrying mains.

JOHN N. CHESTER, M. Am. Soc. C.E.
Vice-President, J. N. Chester, Engineers

Pittsburgh, Pa.
March 9, 1931

Minimizing Chemical Treatment of Domestic Water Supply

SIR: In his paper in the December number, Mr. Weston has ably treated the modern methods of purifying water for domestic use. The advances in water purification have been in the direction of more treatment with chemicals and less by means of natural straining through filters. My observation of the growth of water purification in the United States has been that it has developed from a mere aid to a natural process up to a chemical manufacturing industry. If this tendency keeps up, we shall expect to see sand filtration done away with in the future.

If the expense is not considered, rapid sand filtration with coagulants, followed by slow sand filtration, should be the most desirable type of water purification. This method would eliminate the need of adding such chemicals as chlorine, sulfur dioxide, and ammonia. As a chemist for a large and well known filtration plant, my experience has been that the public prefers a water supply purified with as little chemical treatment as possible.

HERBERT F. SALMOND
Chemist, Municipal Water Works

Springfield, Mass.
February 7, 1931

Control of Stream Development

DEAR SIR: The paper by W. W. Horner, in the January issue, is a timely article on a phase of municipal development too often neglected. What greater service could be rendered than to utilize the labor of men, at this time, to lay a foundation for the future development of parks and recreation centers along unsightly, rubbish-filled streams. In many cases the investment required is very low as compared to the benefits derived in the future.

Unfortunately, the efforts of a single community to improve the conditions along a stream are often inadequate, as the stream in its course passes through several municipalities. In these cases a strong central group backed by adequate legislation is required before conditions can be materially improved. For years the town of Cranford, N. J., made every effort to maintain the portion of the Rahway River within its own territory as a delightful boating and recreational area, only to find that at every freshet the refuse from upstream territory would undo much of its work. It was not until a county commission was formed that real improvements of a lasting and extensive character were made possible throughout the length of the stream.

Very naturally the character of the improvements on any stream will depend upon the use of the adjacent land. It is entirely conceivable that a single stream would, in a business or factory district, be confined to a conduit with a highway above it; at another section, it would be an open stream with park areas along the banks; and at still other sections, it would be held and gradually improved for future development. In the latter case it may be advisable to use selected city refuse to fill in low areas subject to periodic flooding. This could be done under proper regulation and supervision so as not to adversely affect improved sections.

Where the requisite control of the stream can only be obtained by means of state or county commissions, one of the functions of such a commission should be to obtain control of areas which are subject to periodic flooding, for the purpose of preventing the development of such areas into cheap residence or summer camp sites. Experience has shown that uninformed people are attracted to such areas by low prices, but experience has also shown that it would have been better had the development been restricted to more salubrious and secure territory.

C. G. WIGLEY, M. Am. Soc. C.E.
Consulting Sanitary Engineer

Atlantic City, N.J.
February 16, 1931

Drainage Ways Cost Most

DEAR SIR: To follow out Mr. Horner's ideas on municipal drainage, as given in the January CIVIL ENGINEERING, would be to design and construct an engineer's Utopia. Thinking of the matter from its economic and practical side—it is an old story, how very difficult it is to raise funds for even the immediate and visibly necessary improvements. Should we, then, propose to raise large sums that would admittedly not accrue until the second or third generation? We would most likely fail.

Let us analyze the cost of the "Drainage Way System," proposed by Mr. Horner.

1. Open ravines, unless properly maintained and policed, would soon become dangerous to health, littered with unsightly rubbish, and perhaps dangerous for children. The proper upkeep to prevent this would be quite expensive.

2. In communities, such as St. Louis, where a combined system is otherwise possible, separate sanitary systems large enough to include the necessary roof drainage would be quite costly. The treatment of sewage made necessary by lack of occasional thorough flushing and dilution by storm water would also be expensive.

3. As the paper shows, one-fifth of the final cost of closed sewers, if invested ten, twenty, or thirty years ahead, would have bought the drainage ways. That is true, but let us not forget that money at 6 per cent, compounded annually, doubles in value in ten or twelve years, quadruples in twenty-four, and would have more than five times its original value in thirty years. While it is true that the municipality could not collect and hold this money for investment, it must be remembered that

to the people who constitute the municipality it has that value.

4. Speed of contact is a necessary requisite of modern business, as is brought out by constant demands for elimination of congested traffic by the huge sums of money spent on telegraph, radio, air traffic, fire protection and, last but not least, the ever-increasing number of skyscrapers. The extent to which these open ravines would impede traffic can be seen in coast towns, such as Norfolk, Va., where the salt marshes extend through the town like fingers from the sea, and it is often necessary to wall them off by piling and, at great expense, to fill them by dredging. It would be impossible to estimate the tremendous money loss to the industries of the town due to the impeding of traffic by these drainage ways with their necessary occasional crossings.

Taking all these facts into consideration, we will find that after all the drainage-way system is probably the most costly.

As usual, a happy medium is probably the right answer. The city should shoulder the burden of extensive plans and surveys, such as are indicated by Mr. Horner, as far in advance of immediate needs as possible, taking in all of the drainage areas surrounding them, for which it may at some future day be necessary to provide. An effort should then be made to pass laws both in the town and the surrounding areas, which would compel the coordination of all developments so that they would fit in with this general layout. To make this possible, the planning should actually be detailed as far ahead as possible and furnished freely by the city to all concerned.

Rights of ways could then be maintained slightly ahead of their need and, as the city expanded, the open channels would disappear and closed sewers take their places.

ALFRED LEWALD, M. Am. Soc. C.E.
President, Alfred Lewald, Inc.

St. Louis, Mo.
February 7, 1931

Treatment of Small Streams

DEAR SIR: The article by W. W. Horner, in the January number, presents an interesting suggestion for the treatment of small streams lying in cities and adjacent suburban areas. Certainly, if one were planning the development of a municipal area, starting with raw land, pure streams, and sweeping valleys, he would be very foolish to allow streams to be polluted, low land to be filled up, and trees to be destroyed. These preserved in their natural state would be eternal beauty spots, parks, and play spaces that would be of great economic and social value to the community.

Taking conditions in cities as they are, one will rarely find a rivulet that is not an odorous, filthy, open sewer. Even before there is any prospect of urban development, the farmers begin to destroy trees, turn sewage into rivulets, and otherwise injure the valleys. When the developers arrive, they are anxious to secure profit from every square foot of ground, using all flat bottom land as convenient manufacturing sites, railroad layouts, and the streams for sewers as long as they are not too unsanitary in the open. In the present era of interest in city, county, and regional planning, much may be done to save streams, trees, and ravines from wasteful destruction by planning far ahead of developments.

One of the best examples in America of a beautiful stream preserved in its natural purity and beauty is Rock Creek in the City of Washington. This stream flows through a naturalistic park of about sixteen hundred acres that is proving itself a priceless possession to the community.

Let us hope that regional planning commissions will take to heart the valuable suggestions made by Mr. Horner.

C. O. SHERRILL, M. Am. Soc. C.E.
City Manager

Cincinnati, Ohio
February 15, 1931

Some Potential Values of Municipal Water Courses

EDITOR: The paper by W. W. Horner, M. Am. Soc. C.E., in the January issue, is a reminder that in every city and the adjoining country, there will be found along water courses an inharmonious grouping of country estates, modest homes, old farmsteads, truck gardens, quarries, rubbish-dumps, platted lots, squatters' shacks, abattoirs, and other offending uses. The potential value of these water courses to a municipality, large or small, has seldom been recognized. Their value for drainage purposes, for parks, cross-country driveways, or for simple open spaces to preserve running water, trees, landscape vistas, bird refuges, and unspoiled country, has never been given the weight it warrants in the scheme of things.

In many cases these water courses are ruthlessly used for alien purposes because of their drainage value in disposing of waste, and when no economic use can be found by the owner they usually degenerate into unsightly dumps. Such lands, in private ownership, can never be anything but low grade property, unable to bear assessments for any improvement. Sooner or later they become tax-title property, the city thus losing its tax income and paying for such assessments as may have been placed against it. Many of these water courses have a historic value and their reservation by the municipality preserves an interest and charm to the locality. As often happens, it is not until the economic value of such a thing is clearly recognized that much can be done about it.

As I recall, the Des Peres River in St. Louis is about 13 miles long within the city. At \$20 per running foot for a strip $^1/_4$ mile wide, the city would have 200 acres of land at a cost of \$1,500,000, while the estimated cost of the artificial channels and closed sewer tunnels now being constructed approximates \$10,000,000. When land is so plentiful—and it is plentiful in any locality—to permit property costing less than \$1,000 per acre to go for uses that will require such an expenditure for drainage is not good "land planning."

In zoning practice the protection of land subject to overflow or having a high ground-water level, against uses that would require drainage, might be difficult. It is the purpose of zoning to put land to that use to which it is best adapted, but it cannot be zoned for park or for drainage purposes; and if it is zoned for industrial purposes, the use selected probably will not fit in with the surrounding higher reaches. A refusal to accept or record a plat into lots on lands of this character might well be substantiated on grounds of health.

The purchase or condemnation of this land for a public use would perhaps come more nearly within the scope of city planning methods. There would be many public uses along such a water course: a right-of-way for a sanitary sewer, a parkway drive following the open water course, municipal forests, parks, tennis courts, playgrounds, and athletic fields. Land for school build-

ings is required at least every mile in any direction in any city, and the higher portions of the valley floor might be used for school purposes. That part of the land which later proves to be valuable for residence can be alienated when the proper time comes. The economic value of "drainage ways" has been stressed by Mr. Horner; they should be included in every city or regional plan where natural water courses are a part of the topography.

GEORGE H. HERROLD, M. Am. Soc. C.E.
Managing Director and Engineer,
The City Planning Board, St. Paul

St. Paul, Minn.
February 17, 1931

Cultural and Drainage Maps

DEAR SIR: The method of using aerial photographs, described by Mr. Clemens in the January issue of CIVIL ENGINEERING, should enable one to construct a very excellent cultural and drainage map of areas of comparatively low relief, such as exist in the Red River Valley.

There are several points which come to mind in reading Mr. Clemens' paper, the importance of which he probably realized but has not mentioned, but which might be the cause of trouble to others attempting to use the same method. The writer understands that the "aerial control points," compiled by the radial line method from a single flight of photographs at a time, are enlarged from the taking scale of the photographs (±1:18,000) to the scale of 1:10,000, and, at this enlarged scale, fitted to the third-order control points on the tracing sheet on which the map details are to be drawn.

While this procedure assures a satisfactory fitting of the aerial control to the third-order points, it does not prevent discrepancies in horizontal position arising between aerial control points common to adjacent flights. To be certain that this does not occur, it would be necessary to carry on the radial line control work in several strips simultaneously, selecting for intersection points appearing in the overlapped area between adjacent flights. In the event this method could not be used, points common to adjacent flights should be intersected frequently to enable the map compiler to make allowance for discrepancies in position arising from the fact that the control in each strip was independently obtained. It is possible that Mr. Clemens is using either of these methods, although his paper does not make this clear.

The cultural and drainage detail of the map can be advantageously traced from aerial photographs enlarged to approximately the scale of the finished map, provided the area being mapped is of low relief. This provision is a very important one and should be stressed to avoid conveying the impression that this procedure can be followed everywhere with the success reported in this instance. Differences of elevation in the ground surface photographed cause displacement of image points in the photographs, with the result that the points standing at different elevations are not shown in their proper relative positions, and consequently all cultural and drainage detail traced from such photographs is correspondingly in error. When the relief of the terrain is very low, it is possible to adjust the photographs under the radial control shown on the tracing cloth in such a manner as to minimize these errors; but as the relief becomes greater, more and more difficulty is encountered in doing this successfully, until eventually the method fails entirely.

The value of level bubbles as an indication of the tilt in an aerial photographic plate is very questionable. It is realized that the engineer who purchases aerial photographs for mapping uses needs some assurance that the photographs have no greater tilts than are to be expected with good photographic flying, but dependence on level bubbles as an indication of tilt is apt to be misleading. The degree of tilt in a photographic plate can be measured positively to within a few minutes of arc and must be done in connection with photographic plates intended for use in drawing of contour lines by stereoscopic measurements of parallax.

Measurements of tilt by parallax methods on aerial plates on which level bubble indications appeared have shown that these indications were not trustworthy; in fact, the tilt quite often was found to be in a direction entirely different from that indicated by the bubbles. The character of camera support undoubtedly plays a very important part in the behavior of the level bubbles which, in the case of the test just referred to, was of a pendulous type with provision for damping the camera oscillations. Cameras supported in or near their center of gravity may behave quite differently but, until the accuracy of the level bubble indications on cameras with such suspensions have been verified by actual measurement of tilt, level bubble indications should not be regarded as trustworthy.

T. P. PENDLETON, M. Am. Soc. C.E.
Chief Engineer, Brock and Weymouth, Inc.

Philadelphia, Pa.
March 1, 1931

Making Practical Use of U.S. Coast and Geodetic Surveys

DEAR SIR: The article by Major Bowie, in the December issue, is most interesting. The present rate of progress, accuracy of results, and the lowering of costs should be to the U.S. Coast and Geodetic Survey a matter of great satisfaction and pride.

Its surveys serve many scientific and practical purposes. Scientifically, they supply indispensable data for studies in astronomy, geodesy, seismology, isostasy (or study of the equilibrium of the earth's crust), and other subjects. Practically, they are used for controlling topographic surveys needed in every phase of our industrial development—for controlling coastal hydrographic surveys, for military purposes, for general mapping, for geographical and geological studies, for the determination of time, and for a host of other purposes.

There still remains one great undeveloped field of usefulness to which these surveys should be put, and that is a more extensive use of the Survey's triangulation stations and bench marks by engineers and surveyors generally, particularly by those in the service of the several states.

In early times, surveys were made almost entirely with the compass. Many of these fail to give the date and magnetic declination, thus rendering retracement practically impossible, if the corners have been lost. Many such surveys are still being made.

Within the past seventy-five years, millions of more accurate surveys have been made with the transit, the courses being computed either from a true, magnetic, or assumed meridian, and the coordinates from an arbitrarily assumed origin, while the levels and contours are based upon an assumed datum. Hence the millions

of miles of highway, railway, transmission-line, pipeline and canal locations, and the many thousands of square miles of topographical and other area surveys, can scarcely be expected to serve any useful purpose other than that for which each was made. Thus, when viewed collectively, they represent only hopeless confusion. Had they been based upon a common origin of true meridianal coordinates and mean sea-level datum, they would, with their unchangeable bearings or azimuths, have served mankind for all time to come in many useful ways.

Owing to the present scarcity of Government stations, it is not to be expected that all individuals or corporations would stand the expense of having their surveys tied into stations miles away except in the case of extensive ones, but where surveys are made by a state the matter is different.

Consider, for example, the design of our several state highway systems. Had the locating engineers been required to base all of their surveys upon the Government stations and to secure a reasonable accuracy as well as to place at suitable intervals permanent monuments with geographical coordinates, azimuths, and elevations made available, the states would have amassed for themselves and for the public, at very little additional expense, data of almost unlimited value. Some engineers seem to regard the Government stations with a sort of bewildered awe. They do not realize that, so far as their jobs are concerned, the coast and geodetic method may be just as simple and no more accurate than their own, and that its chief and exceedingly great advantage is that it correlates or coordinates all surveys into one uniform system, thereby making each survey permanent, usable for myriad purposes, and consequently something of very great value.

The coast and geodetic survey must of necessity be composed of highly trained engineers, mathematicians, and scientists, whose work must be done scientifically, and with unbelievable accuracy, in order to make the work of the rank and file of engineers in the field simple and easy. In this they have succeeded well.

Moreover, this organization is both courteous and friendly to those who seek its help. I no longer feel diffident about consulting it, for it has made me feel that its pleasure is to help wherever help is needed. I would like to see a well organized, joint movement—embodying every civil engineering society, association, and club in America—petition Congress to appropriate sufficient funds to enable this bureau to complete its triangulation of the country within half the time now anticipated, in order that the country and the engineering profession might more quickly reap to the fullest the advantages offered by its achievements.

George F. Syme, M. Am. Soc. C.E.
Senior Highway Engineer
State Highway Commission

Raleigh, N.C.
February 10, 1931

Tying Into Government Surveys

Dear Sir: Major Bowie's description of present-day triangulation methods, in the December issue, comes at a most opportune time.

For many years engineers have looked upon triangulation as of concern only to those engaged in the mapping work of the Government. General interest in precise control methods has been greatly stimulated recently by the discussions in the Survey and Mapping Division of the Society. The mapping of large areas along the Mississippi River and its tributaries during the past two years has added to the interest in this subject.

The diagram of errors of closure in the Western net shows clearly the truly remarkable results obtained in this work. It should inspire confidence in the accuracy of the position given for points within this net and thereby increase the use of these valuable data. To the writer it was of further interest, in that it seems to bring out rather strikingly the effect of compensation of error. With the use of identical methods, in nearly every case the closure of large circuits is markedly better than that obtained in the smaller ones.

It is important for the profession to realize that triangulation not only is necessary to properly controlled surveys of extensive areas, but that, when executed under proper conditions, it enables such areas to be controlled better, more quickly, and at less expense than any other method adequate to serve this purpose.

For the past fifteen years the writer has been using the U.S. Coast and Geodetic Survey triangulation data whenever possible as control not only for topographic mapping, but also in property surveys, which can always be relocated with certainty by any competent engineer even when every property monument on the survey itself has been lost or destroyed. The many advantages of such ties to the permanent triangulation stations of the Government system are apparent to anyone who has much to do with property surveys either in rural or city districts.

Yet indicative of how little use is made of this data for such purposes by the profession in general is the fact that, within the past year, the adequacy and advisability of this type of property monument reference has been questioned by two of the larger title guarantee companies in the State of New York. In one instance this was on a survey and subdivision of approximately three thousand acres; in another, of twenty thousand acres. In both, the property value involved was large and the loss or destruction of property corner monuments would have involved serious consequences.

W. N. Brown, M. Am. Soc. C.E.
W. N. Brown, Inc., Engineers

Washington, D.C.
February 15, 1931

Canadian Geodetic Survey

Dear Sir: I read with great interest the paper by Dr. William Bowie, in the December issue. On account of the contiguity of Canada and the United States, it is natural that in many respects the geodetic methods of the two countries are similar. Owing to the close personal relationships between the geodetic organizations of the two countries, improved methods in either country are readily accepted by the other when such changes can be used.

Because of variations in latitude, topography, and development, the methods employed by the Geodetic Survey of Canada and the U.S. Coast and Geodetic Survey show certain differences. The field season in Canada is considerably shorter than it is in the United States, especially the southern part, so that the progress of our field work cannot always be as great. Also the large developed areas in the eastern United States, with comparatively flat topography and high timber inter-

spersed over it, have their Canadian counterpart only in a small area of southern Ontario. This situation has made it inexpedient for the Geodetic Survey of Canada to use steel towers, which have been utilized so successfully in the eastern part of the United States.

A minor difference in the trend of modern practice in the two countries is that of instrumental equipment. In the eastern areas at present being covered by the U.S. Coast and Geodetic Survey, motor transport is commonly suitable, so that a saving of weight of instruments is not so important as it is in many parts of Canada where triangulation is being laid down. For this reason the theodolites used on primary triangulation in Canada have had to be of the minimum weight, and the instrumental equipment at present used in the two countries varies quite considerably, although the types used in both countries are modern in every respect.

Canadian topography has permitted another difference in triangulation operation to that of the United States, that is the use of the aeroplane. A large part of eastern and northern Canada is covered with what is known geologically as the pre-Cambrian shield, characterized by a great many lakes which make admirable landing places for pontoon-equipped aeroplanes. The northern part of Minnesota is very similar in this way to a considerable part of northern Canada. As many of these parts of Canada are not yet provided with roads, the operation of planes is the natural answer to a difficult transportation problem.

The reconnaissance for triangulation can be very satisfactorily performed by plane, although so far it has been found necessary to check the aeroplane results by ground examination. It is hoped, however, that stereoscopic, oblique photographs from the aeroplane will solve, to a considerable extent, the question of the intervisibility of triangulation stations and will preclude the necessity of this ground check. The method is naturally very quick. As an example, it might be pointed out that triangulation reconnaissance, covering 500 miles of northern Ontario, is to be carried out by ski-equipped planes this winter in a period of about a month, whereas the same operation would take from two to three seasons were ground methods only employed.

During 1929 and 1930, in one district the station-preparation, light-keeping, and angular-measurement parties were entirely transported by an aeroplane detachment of two planes on non-photographic days, photographic days being reserved for aerial photography for mapping, forestry, mineral, water-power, and other investigations. This scheme of operation of the planes makes for their most economical use, and the operations to date have been most satisfactory.

NOEL J. OGILVIE, M. AM. SOC. C.E.
Director, Geodetic Survey of Canada

Ottawa, Canada
February 10, 1931

Bureau of Standards Should Be Credited

DEAR SIR: I wish to call your attention to a curious mistake in the otherwise admirable symposium in the March issue of CIVIL ENGINEERING, "Federal Bureaus Aid the Profession." The last paragraph under the title "The Bureau of Public Roads," on page 496, refers to the tests made by the Bureau of Standards on half-size models of the columns of the Hudson River and Kill van Kull bridges. It should have been inserted on page 493 of my article on the Bureau of Standards, in the left column, under the paragraph heading, "To Aid in Designing Steel Columns."

I think it is only fair to point out this error which may give the reader a wrong impression.

GEORGE K. BURGESS
Director, U.S. Bureau of Standards

Washington, D.C.
March 18, 1931

Joint Freight Terminals Scouted

SIR: The article by Colonel Jonah, "Coordination of Terminals," is of interest. As a general proposition, joint passenger terminals are advantageous in cities of medium size, for they facilitate the transfer of passengers from one road to another. Coordination of freight terminals, however, does not generally seem to be advantageous on account of the frequent conflicts of employees of different lines, which would arise. Moreover, the road in any city which has greatly superior freight terminals could not ordinarily afford to let its competitors use them. Confusion would arise as well as disputes about priority of movement and handling.

W. H. COURTENAY, M. AM. SOC. C.E.
Chief Engineer, Louisville and Nashville Railroad Company

Louisville, Ky.
February 20, 1931

Straighten the Mississippi

DEAR SIR: The paper by Mr. Coleman on the Mississippi River, in the February issue, appeals to me as the most concise and clear statement of the problems involved that has been presented. I agree with him; the theory that nature abhors straight lines and that, therefore, the more crooked the stream the nearer it approaches the ideal, is in error.

We might, to advantage, materially straighten the river. Where and to what extent this should be done are questions which cannot be answered until we have more definite knowledge of the slopes producing velocities that may be safely sustained. A study of this subject should be one of the first undertaken in the Hydraulic Laboratory when it is established.

Reforestation should be considered more seriously than from the viewpoint of a mere aid to flood protection. There are many so-called farms in the Mississippi Valley which are not profitable under average conditions. Apparently this country has a surplus of lands under cultivation, this fact having been demonstrated under both flood and drought conditions. By returning these unprofitable agricultural lands to their original conditions, much of the economic loss, as well as of the physical suffering, would be obviated and the work of flood protection would, at least, not be harmed.

BAXTER L. BROWN, M. AM. SOC. C.E.
Consulting Engineer

St. Louis, Mo.
February 11, 1931

City Control Surveys

To the Editor: It is gratifying to learn from reading Major Bowie's paper in the December issue, of the increased speed with which the U.S. Coast and Geodetic Survey now executes the triangulation of our country. The results of this triangulation are of broad but very practical value in a scientific sense, since they furnish data for the determination of the shape of the earth and for other problems of geodesy. They are of more immediate practical value in controlling surveys upon which engineering works of all sorts are designed and constructed. Since our population is now 56 per cent urban, it may be said that one of the most important uses to which the Federal Government's triangulation may be put is that of providing positions for the more detailed controlling surveys of cities and metropolitan areas in general.

This account of modern triangulation practice clearly describes improvements in technical procedure and serves to give an idea of triangulation as it is executed for continental control. The triangulation of city areas, which is itself based upon the continental survey, is performed in accordance with the principles and practice described by Major Bowie. Certain modifications are, however, essential in triangulating densely populated urban areas; and it is my purpose to describe some of these variations in practice.

Although, in some instances, lights are used for signals in city triangulation, this is not the universal practice. Many of the sights are so short that a signal may be easily seen and accurately read by daylight. At other stations it is sometimes necessary, on account of haze, to observe upon signal lights during the daytime. The chief obstacle to observing upon lamps as a regular practice is the difficulty of finding civil service employees to do this night work. This objection applies not so much to the triangulation as it does to the work of precise, or first-order traversing, which ordinarily succeeds the triangulation and is performed by some of the same personnel. It is desirable to run such traverses at night, and this is the practice of the U.S. Coast and Geodetic Survey; but it is, in most cases, not feasible to ask city employees to work for long periods on night programs.

The signals, which are to be read in daylight, ordinarily consist of rods of triangular cross section with a 6-in. face. The face of such a rod is centered upon a pointed steel shoe, which fits into a conical hole in the bronze mark for the station The rod is guyed in place with wire. By rotating it so as to face the observing station, all errors due to phase, or unequal illumination of the sighted image, are eliminated. On longer sight lines it is customary to mount on the top of the rod a triangular-shaped target, painted red and white as is the rod, and having a side length of 30 in.

Erection of towers for the elevation of signals is rarely necessary in city triangulation, as a thorough reconnaissance will usually develop a scheme for using high, well constructed buildings, where hills themselves are not available. Where the Federal Government has triangulation stations available locally for determination of true length and geographic position, one triangle side length, measured upon the ground, will be sufficient to complete the triangulation. In cases where the Federal work is not available, a minimum of two ground base lines is, of course, necessary. The high accuracy which is requisite in city control surveys makes it necessary to measure base lines at more frequent intervals—as measured by the number of intervening triangles—than is the case in the Federal continental triangulation. The procedure in measuring base lines is now, as Major Bowie says, so much simplified by the use of invar tapes that an ample number of ground bases is economy.

It is usually necessary in city triangulation to employ both the direction type of theodolite, described in Major Bowie's account, and the repeating type. This is because atmospheric and other conditions quite commonly necessitate a larger number of observations for the determination of an angle than is secured in the observing program of the direction instrument. Lateral refraction, caused by heating of the air near chimneys and smoke stacks, or near high buildings and hills, is extremely troublesome in city work, the one solution being to get a larger number of readings, at different hours of the day and on different days.

Triangle closures, under standard specifications for city work, should be kept within a maximum of 5 sec. and an average of 1.5. After having inspected angles for computing the triangulation in a certain section, it is sometimes found that the length, as carried through from base line to base line, exceeds the allowable limit of closure, which is usually 1:100,000. Re-observing the angles will then usually give new and slightly different values, which also result in acceptable triangle closures and, when introduced into the adjustment, give satisfactory base-to-base length agreement. This "fluid" condition of the triangles is believed to be due almost entirely to lateral refraction and cannot be overcome in any way, except by selecting from a large number of observations in these troublesome areas the angular values which will, while conforming to the triangle closure requirements, give the best length agreement.

R. H. Randall, M. Am. Soc. C.E.
President and Chief Engineer, R. H. Randall and Company, Inc.

Toledo, Ohio
February 15, 1931

The Atchafalaya River Bridge

To the Editor: In his valuable article on the Atchafalaya River Bridge, in the February issue of Civil Engineering, Mr. Purdon shows how a very troublesome situation was successfully met. His paper is a distinct contribution to engineering knowledge and practice.

A lesson to be learned is that, on a river of this kind, it is as important to span the bank as it is the channel. There have been other bridges in lower Louisiana, where piers have been moved by the sliding and caving of banks. A pier should not be located at the foot of the bank slope in alluvial deposit. It should be kept some distance toward the channel from the foot of the bank, and in spanning the bank the piers should be outside of a slope line of three to one.

I am familiar with the territory in question and with the Atchafalaya River, and know how its progressive enlargement of channel section, both in width and depth, has been destructive to bridges along its course. Confronted with an emergency that threatened to be disastrous to a big enterprise, Mr. Purdon's prompt and skillful handling was most timely and efficient.

F. G. Jonah, M. Am. Soc. C.E.
Chief Engineer
St. Louis-San Francisco Railway Company

St. Louis, Mo.
February 16, 1931

SOCIETY AFFAIRS

Official and Semi-Official

Norfolk Is Next

The Spring Meeting of the Society convenes in Norfolk, Va., Wednesday morning, April 15, 1931. As guests of the Virginia State Section and of the City of Norfolk itself, members of the Society, who travel to this land of recreation, sunshine, and Southern hospitality, will find a wonderful program filling with pleasures and recreational opportunities every minute of a three-day meeting not already occupied by a selected group of technical meetings and Division sessions. Can you resist? Can you afford to miss it? Many friends will be there and the opportunity to extend your acquaintance is without an equal. Railroad fares have been reduced for our benefit so that, upon presentation of the certificate, a special round-trip ticket can be purchased for one and one-half times the straight one-way fare.

A splendid group of papers, which might be classed under the heading of problems concerning transportation by rail, by water, and by air, will occupy a very conspicuous part of the program on the first day. To begin this symposium, the Hon. J. Gordon Bohannan, Chairman of the State Port Authority of Virginia, will speak on "The Port of Hampton Roads," followed by Maj.-Gen. Lytle Brown, Chief of Engineers, who will explain the problems of navigable channel maintenance and flood protection on the Mississippi River. A third paper takes up "Transportation Problems of the Railroads," as viewed by Elisha Lee, Vice-President of the Pennsylvania Railroad, while "Coast Erosion and the Remedies" will be presented by Lt.-Col. E. J. Dent, Corps of Engineers.

In the afternoon, the scene will shift to the air, when "Aerial Commercial Transportation" will be presented by Paul Henderson, President of National Air Transport, Inc. It is fortunate that several flying fields are located in the immediate vicinity of Norfolk, among them Langley Field, one of the Army's largest air stations, and the Naval Operating Base at Hampton Roads. "Army Aviation" is the subject of a paper scheduled to be given by Capt. George C. Kenney of the Air Corps, while the subject of "Naval Aviation" will be responded to by Capt. Kenneth Whiting of the United States Navy.

In the late afternoon the Student Chapter Conference meets to discuss Student Chapter problems, while at the same time the Southern Regional Meetings Committee holds its conference.

The ladies of the party will enjoy, on Wednesday, a drive along the shore to Cape Henry, to the Lawson Hall Garden, and to Virginia Beach, where, at the exclusive Cavalier Hotel, they will be entertained at luncheon. In the evening, the entire party will gather together at the Monticello Hotel in Norfolk, to enjoy a more formal dinner and address, closing the evening with dancing.

Four Technical Divisions Meet

On Thursday morning, April 16, four Technical Divisions will hold simultaneous meetings, the Surveying and Mapping Division, the Highway Division, the Waterways Division, and the Sanitary Engineering Division. Each has its own special field to cover. There are three papers on surveys: one by Capt. Raymond S. Patton, Director of the U.S. Coast and Geodetic Survey, which explains the usefulness of geodetic control surveys; a second by Gerard H. Matthes, Engineer of the U.S. Engineer Office of Norfolk, which will take up methods of conducting surveys for the study of rivers; while M. A. Butler, of Ulen and Company, has an interesting paper on the application of aerial photography to railroad location.

Before the Highway Division, "Convict Labor for Highway Construction" will be presented by Henry G. Shirley, of Richmond. This is to be followed by a short symposium on problems of "Arbitration on Public Works Contracts," various phases of which will

Sketch of Norfolk and Vicinity

be presented by Charles H. Stevens, Chief Engineer of the Philadelphia Department of Transit, and by Philip A. Beatty, of the Bureau of Municipal Research, of Philadelphia.

The Waterways Division will add to the data already presented on transportation problems by considering three papers prepared by officers of the Corps of Engineers: "The Port of Baltimore," prepared by Lt.-Col. Warren T. Hannum, District Engineer of Baltimore; "The Waterways of the National Capital," to be presented by Maj. J. D. Arthur, Jr., District Engineer, Washington, D.C.; and a description of the operation, maintenance, and use of the "Atlantic Intracoastal Waterway," by Maj. Gordon R. Young, District Engineer of Norfolk.

The Sanitary Engineering Division will offer papers on vital municipal utilities: Walter H. Taylor, Director of Public Works of Norfolk, has prepared a paper on "Norfolk's First Essentials for Sanitation, Water Supply, and Sewerage;" and J. N. Chester of Pittsburgh, Pa., has prepared a discussion on Norfolk's water supply. In addition to these matters of local interest, Frank A. Barbour, Boston, Chairman of the Division's Committee on Water Supply Engineering, will render his committee's report. Then, too, the committee appointed to study the New Jersey Sewage Experiments has its report ready, and the committee's chairman, George T. Hammond, Brooklyn, will present it.

Thursday finishes the presentation of technical papers, and at noon all meetings will be adjourned, after which members will board a steamer furnished by the Pennsylvania Railroad, to make an inspection trip of the harbor. En route to the Newport News Shipbuilding and Dry Dock Company's shipyard, box lunches will be supplied. At the shipyard, the operations connected with building many types of marine carriers and heavy hydraulic machinery will be seen. At Sewall's Point, the coal piers of the Virginia Railroad are of interest.

At the Naval Training Station and Operating Base, the steamer will be left behind. Here a dress parade will be staged for the enjoyment of those who make the trip. Automobiles and buses will return the party to the hotel in time to prepare for the informal dinner, for which the dining room of the Monticello Hotel has been reserved. An address by the Hon. W. E. Carson on "Virginia Shrines," which will follow the dinner, will be an excellent preparation for the all-day Friday excursion for members, guests, and their ladies.

Virginia is replete with points of historical interest and many of them, fortunately, are near enough to Norfolk to make visits to them possible. The sketch reproduced here indicates some of the points on the itinerary loop which will take in Newport News, Yorktown, Williamsburg, and Jamestown. The caravan will return to Norfolk via the new James River lift bridge.

For those who can remain for Saturday, there are enticing golf courses to consider, more shopping for the ladies, the inspection of some engineering project, time for which could not be found in the preceding crowded days, or boating, fishing, or other recreational sports.

Norfolk welcomes you and bids you take this opportunity to become better acquainted with her beauty, her history, and her hospitality.

Gavels and Sentiment

Presiding officers, from time immemorial, have been vested with a badge of office, a symbol of authority—some actual means of maintaining order at meetings over which they preside. Silverware, water pitchers, goblets, and even coffee cups have been drafted for use in emergencies, but well ordered organizations supply their presiding officers with a gavel. Even these gavels take on sentimental value as they are banded, engraved, and presented to a retiring president.

They have been made of rare and interesting woods, such as those carved from a 25,000-year-old log found in a glacial drift in Washington, now used by the Tacoma and the Seattle Sections. The Los Angeles Section has utilized a set of musical chimes to call its meetings to order. The Society possesses a bell cast from the same metal and in replica of one of the bells of the carillon in the Louvain Memorial Clock Tower. This may be used to call Society meetings to order. But the elaborate layout, designed and recently presented to the Cleveland Section by its retiring president, George B. Sowers, is unique, distinctive, and original.

As shown in the illustration, the anvil is an I-beam, representing the end section of a floor beam. Like all well designed engineering structures, each detail has a reason. It is made of aluminum, a modern structural material. Clip angles connect the I-beam with a plate on which the emblem of the Society is engraved, symbolic of the connection of the Local Sections to the Society. Typifying the old and the new structural schools, the angles are riveted to the I-beam but electrically welded to the emblem.

ANVIL PRESENTED TO THE CLEVELAND SECTION

The gavel is a piece of Cuban wood, reinforced with aluminum bands, to prevent splitting should the deportment of the Cleveland Section become difficult to control. A portion of the aluminum handle has been stained blue to match the emblem. On the anvil are engraved the names of the former presidents of the Cleveland Section, to which list it is proposed to add, from year to year. A more unique order-preserving badge of office is yet to be offered.

Appointments of Society Representatives

P. W. HENRY, Chairman, R. W. HEBARD, GEORGE H. PEGRAM, GEORGE W. KITTREDGE, and JOHN R. SLATTERY, Members Am. Soc. C.E., have been appointed as a committee of the Society to make inquiry relative to the conditions surrounding the employment of engineers in the Union of Socialistic Soviet Republics.

M. S. KETCHUM, M. Am. Soc. C.E., was appointed to represent the Society at the meeting of the Western Society of Engineers, held in Chicago, February 25, when the Washington Award was presented to Ralph Modjeski, M. Am. Soc. C.E.

W. B. GREGORY, M. Am. Soc. C.E., has been appointed to represent the Society at the Annual Meeting of the American Association for the Advancement of Science, to be held in New Orleans on December 28, 1931.

NATHAN B. JACOBS, M. Am. Soc. C.E., has been appointed Society representative to the International Federation of Housing and Town Planning, and the International Housing Association, each of which organizations is to hold meetings in Berlin during the period of the German Building Exposition, May 9 to August 9.

GEORGE W. FULLER, M. Am. Soc. C.E., has accepted an appointment as the Society's representative on the Sectional Committee on safety Code for Industrial Sanitation, under the auspices of the American Standards Association.

FRANK E. WINSOR, Vice-President Am. Soc. C.E., as the official representative of the Society, will attend a testimonial dinner to John R. Freeman, Hon. M. Am. Soc. C.E., to be given by a committee in Providence, R.I., on Tuesday, April 21, 1931.

Year Book for 1931 Released

As this number of CIVIL ENGINEERING goes to press, the 1931 edition of the *Year Book* is well under way, and it is expected that it will be in the hands of the members shortly after April 1. A *Year Book* does not "just grow," like Topsy—it goes through certain well defined stages of development, according to a schedule laid out in advance, and some revision is made in it each working day in the year. Intensive work, however, begins the first of February and lasts until the middle of March, and at that time almost every one at Headquarters contributes in some way to the publication. On the first day of March the "forms close," and no further changes of address or additions of names are made after that date.

The new make-up of the *Year Book* has been the subject of much study on the part of the Committee on Publications. The most striking change is the arrangement of the list of members in two columns and the placing of the date and grade of membership before the address, rather than at the end, as in previous years. It is believed that these changes make for ease of reading, and allow also for the insertion of a few additional names on each page. The list of deceased members, which has been growing unwieldy, in the last few years, has been omitted from the present edition, except for those who have died since the last *Year Book* was issued.

A Useful Gift

A year ago the Society came into the possession of a set of TRANSACTIONS, dating back to Vol. 35 (July 1896), in cloth binding. These were given by Mrs. Pratt from the library of her husband, the late W. A. Pratt, M. Am. Soc. C.E., with the request that they be passed on to some technical school which would find suitable use for them.

As no such need was apparent at the time, the entire set was held in reserve. Sure enough, in due course, the need became apparent. On February 9, 1931, an appeal came from the Agricultural and Technical College of North Carolina, requesting a complimentary set of our publications to take the place of those lost when its library was completely destroyed by fire.

Accordingly, Mr. Pratt's set was shipped immediately to the college and, for good measure, the latest volume was added to bring it up to date. The Society is glad to have acted as a sort of clearing house in this instance to help translate the generous offer of Mrs. Pratt into actual accomplishment. A worthy gift has helped a worthy cause.

Keeping Society Contact

Radio communication is wonderful enough of itself but when a radiogram was recently received from a member in the Philippine Islands, the immense usefulness of the radio made a greater impression. It may not be well known that a group of owners of amateur radio stations have organized themselves into the American Radio Relay League, the members of which, for the sole pleasure of operating, receive messages and relay them to their destination by radio, or by mail if located near the person addressed.

In the case of the message above referred to, it was apparently picked out of the air from Manila by an amateur station in Churdan, Iowa., was re-radioed by that owner, again picked up by an operator in Passaic, N.J., and mailed by him to Society Headquarters. Such a gratis service deserves mention and the members of the American Radio Relay League have the thanks of the Society for it.

News of Local Sections

ALABAMA STATE SECTION

The first meeting of the newly organized Alabama State Section was held in Birmingham on February 27, with 56 members and guests in attendance. The election of officers for the current year resulted as follows: John A. C. Callan, President; A. Clinton Decker, First Vice-President; Robert D. Jordan, Second Vice-President; A. R. Peyton, Third Vice-President; and George J. Davis, Secretary-Treasurer.

CENTRAL ILLINOIS SECTION

Election of officers for 1931 was held by the Central Illinois Section at the annual dinner meeting on December 2, 1930, the results being as follows: J. J. Woltmann, President; H. H. Jordan, Vice-President; and Rex L. Brown, Secretary-Treasurer. The feature of the occasion was a lecture by Professor H. E. Babbitt, of the Department of Civil Engineering at the University of Illinois, his subject being "Engineering Kinks Abroad."

No business was transacted at the meeting of the Section held February 11, 1931. A theoretical discussion of the action of reinforced concrete was given by Prof. H. M. Westergaard, of the Department of Theoretical and Applied Mechanics, University of Illinois.

CONNECTICUT SECTION

A dinner meeting of the Section was held at the City Club, Hartford, February 5, 1931, in honor of Henry R. Buck, recently elected Director for District No. 2 of the Society. The work that is before the Society at present was discussed by Mr. Buck. Stereopticon slides were presented to illustrate such interesting projects as the "Westchester County Park System" and "Carquinez Strait Bridge."

DAYTON SECTION

At the regular monthly meeting of the Section, held February 9, there was some discussion regarding the proposed Engineers' Registration Bill, and a committee was appointed to make a study of the bill. A talk on the rolling of wide-flanged steel beams was given by B. F. Brock, Structural Engineer of the Carnegie Steel Company; and a number of lantern slides, illustrating the operation of the Carnegie Plant, were shown. The attendance numbered 25.

ILLINOIS SECTION

Accounts of the various papers, presented before the City Planning and Structural Divisions of the Society at the Annual Meeting that took place in New York in January, were given at a meeting of the Section held in Chicago, January 30. The desirability of keeping in touch with state legislation affecting engineers was emphasized, and a motion was made and carried that a committee be appointed to make the necessary contacts.

IOWA SECTION

The Iowa Section held a meeting in Des Moines, February 10, with 40 members in attendance. Two of the brief talks by Student Chapter representatives that have come to occupy a prominent place on programs of Iowa Section meetings were given by Floyd Skow, of the Iowa State College Student Chapter; and Maurice L. Tanner, President of the State University of Iowa.

LOS ANGELES SECTION

Preceding the regular meeting of the Section, held February 11, the Junior Forum heard an interesting talk on "The Construction Plans and Specifications of the Hoover Dam." The subject of the evening was the design of the new South California Edison Building, which was handled by H. L. Doolittle, Chief Designing Engineer, and C. B. Carlson, Structural Designing Engineer, both of the Edison Company. This building is considered a splendid example of modern construction, some of its interesting features being complete air conditioning and a super-rigidity to withstand the effect of earthquake stresses. It has been reported that the Ethics Committee is considering the San Gabriel Dam matter, and a recommendation is expected soon.

On February 25, the Sanitary Group of the Section held its monthly meeting. At that time H. A. Jewett, Water and Sewer Inspector of the Los Angeles County Health Department, spoke on "Sanitary Requirements of Swimming Pools;" E. B. Hoag, of the Beeson Engineering Company, spoke on "Mechanical Equipment for Swimming Pools;" and A. M. Rawn, Assistant Chief Engineer, Los Angeles County Sanitation Districts, described the "Design of Sludge Digestion Tanks," used by the Districts.

MARYLAND SECTION

On February 4, the Maryland Section sponsored a joint meeting with the local sections of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Engineers' Club of Baltimore. Of great interest to the audience was an address given by Robert Ridgway, Past-President Am. Soc. C.E., and Chief Engineer of the Board of Transportation, City of New York, on "The Growth of the Rapid Transit System in New York." In his talk, which was illustrated by lantern slides,

Mr. Ridgway brought out the fact of the increasing cost and difficulty of providing the necessary subways, and spoke of the ingenious way in which some of the very difficult engineering problems have been handled.

New York Section

Increasing interest in New York Section activities appeared to reach a climax on February 18, when 750 members and their guests attended a Section meeting. A paper was presented by Col. J. R. Slattery, Deputy Chief Engineer of the Board of Transportation of New York, on the subject of the East River Vehicular Tunnel. Preceding the technical session, a motion picture entitled "The Story of Sulfur" was shown through the courtesy of the Texas Gulf Sulfur Company. The Membership Committee has recently completed a campaign for new members, which practically doubled the membership of the Section, now nearly 1,200. A new campaign is about to be started to enroll in the New York Section every member of the Society residing in District No. 1.

At the meeting of March 18, a timely paper entitled "How is the New York City Water Supply Demand for the Next Decade to Be Met?" was presented by William W. Brush, Chief Engineer, Bureau of Water Supply, New York City. Mr. Brush pointed out that New York's present consumption of 141 gal. per capita will increase, if not curtailed, to 151 gal. per capita or a total of 1,268 m.g.d. by 1940. To meet this demand 930 m.g.d. are now available to which should be added by 1938, 140 m.g.d. from the Delaware River system and another 140 m.g.d. from underground resources on Long Island and Staten Island.

Northeastern Section

The tenth annual meeting of the Northeastern Section was held in Boston, January 31, with 107 members and guests in attendance. Officers for 1931 were elected as follows: Edward H. Cameron, President; H. K. Barrows, Vice-President; and H. P. Burden, Secretary-Treasurer. Upon the conclusion of the business session, interesting talks were given by Dr. Karl Taylor Compton, President of the Massachusetts Institute of Technology, and Frank E. Winsor, Vice-President Am. Soc. C.E., and Chief Engineer of the Metropolitan District Water Supply Commission.

Philadelphia Section

The popularity of social gatherings is attested by the steadily increasing attendance at the social dinners and meetings held annually by the Philadelphia Section. The seventh of these occasions, held at the Engineers' Club, February 20, was partly a commemoration of Washington's Birthday. There were 190 members and guests in attendance at the dinner, and over 200 at the meeting following.

Sacramento Section

A motion picture entitled "The Story of Rock Drilling," issued by the U.S. Bureau of Mines, was shown at a meeting of the Section held January 20. The installation of officers took place at the annual dinner, held January 22, with 169 in attendance. Other meetings were held January 27 and February 3, the speaker for the first occasion being R. L. Egenhoff, of the U.S. Corps of Engineers, and for the second, Steward Mitchell, of the State Division of Highways.

San Francisco Section

Election of officers for the year 1931 took place at a meeting of the Section, held at the Engineers' Club, December 16, 1930, the results being as follows: L. B. Reynolds, President; H. H. Hall, Vice-President; and Harold B. Hammill, Secretary-Treasurer. At the conclusion of the business session, an address was given by Prof. Dexter S. Kimball, Dean of Engineering, Cornell University, on the subject of "Technological Unemployment."

A special meeting of the Section was held December 22, with 95 members and guests in attendance. The speaker of the evening was Arthur Tyndall, Chief Executive, Main Highways Board, Wellington, New Zealand, who discussed the effects of the 1929 New Zealand earthquake upon railway and highway structures and described the Arapuni Hydro-electric Project.

St. Louis Section

At the February meeting of the St. Louis Section, J. W. Kelly, of the Research Laboratory of the Portland Cement Association, spoke on monolithic concrete structure, the subject being illustrated by numerous lantern slides and photographs. There were 30 in attendance.

Seattle Section

On February 19, a meeting of the Section was held at the Engineers' Club, with 54 members in attendance. After announcing the appointment of various standing committees for 1931, the president introduced as guests and speakers for the evening: Col. Chas. F. Abbitt, Managing Director, and Lee H. Miller, Chief Engineer, of The American Institute of Steel Construction.

Tacoma Section

An election of new directors, held by the Section February 9, resulted in the election of the following: Homer Blair; W. J. Roberts; and Wilbur Raleigh. These members, with the officers for 1931, will constitute the new board as authorized by the constitution adopted by the Section at its January meeting. An address was given by T. G. McCrory, State Highway Engineer, who presented a history of the state highway system from its modest beginning to the present biennial budget calling for $18,-000,000.

Texas Section

It has been reported that the Texas Section's new Committee on Regional Activities has been enthusiastically received and promises to be a valuable factor in the work of the Section. At the time of closing the 1930 books, it was found that the total membership for that year was 254, an increase of 9 members over the previous year.

Toledo Section

At a meeting held January 2, the Toledo Section elected officers for the current year as follows: W. G. Clark, President; A. S. Forster, First Vice-President; H. O. Hem, Second Vice-President; and P. W. McDonnell, Secretary-Treasurer. These four officers, with the retiring president, A. Gardner, constitute the 1931 Board of Directors of the Toledo Section. A talk was given by R. H. Randall on the triangulation survey work being done by his company for the City of Toledo.

Student Chapter News

Princeton Engineering Society Student Chapter

There were 40 in attendance at a meeting of the Chapter, held February 17. The speaker of the evening was Lt. W. P. Roop of the Construction Corps of the U.S. Navy, who outlined the work of the U.S. Experimental Model Basin at the Navy Yard in Washington.

University of Arizona Student Chapter

It has been discovered that interest in the regular monthly meetings of the University of Arizona Student Chapter is greatly stimulated by the plan of combining the program with a dinner meeting. The February meeting of the Chapter, held in Tucson, was especially successful as, in addition to the regular student attendance, there were 22 visiting engineers present. Talks were given by C. H. Young, President of the Central States Engineering Company, and W. H. Kirkbride, Chief Engineer of Bridges and Structures for the Southern Pacific Railroad.

Group of Seniors from the University of Arizona Student Chapter

A Preview of Proceedings

In addition to a wealth of discussion, the April number of PROCEEDINGS will bring to its readers two major papers of more than usual importance and interest—one on run-off formulas that are of general application, and another on design methods for multiple skew arches.

ANALYSIS OF MULTIPLE SKEW ARCHES ON ELASTIC PIERS

Early in 1924, J. Charles Rathbun, M. Am. Soc. C.E., presented his paper "Analysis of the Stresses in the Ring of a Concrete Skew Arch." Since then his right to be recognized as one of the foremost authorities on this intricate subject has been undisputed.

That paper was a mathematical analysis of the stresses in a single-span skew arch with fixed ends. His present study, "Analysis of Multiple Skew Arches on Elastic Piers," is an extension of the first, to include skew arches of more than one span. By making the angle of skew equal to zero, Professor Rathbun illustrates how the method may be applied to the multiple right arch on elastic piers. The paper also includes a solution of the two-hinged skew arch. Although not especially long, it is divided into four parts, as follows:

Part I. An outline of the theory

Part II. A method of computing the reinforcing steel required and the unit stresses that occur in the concrete

Part III. Application of the theory to the analysis of a skew arch with approach spans

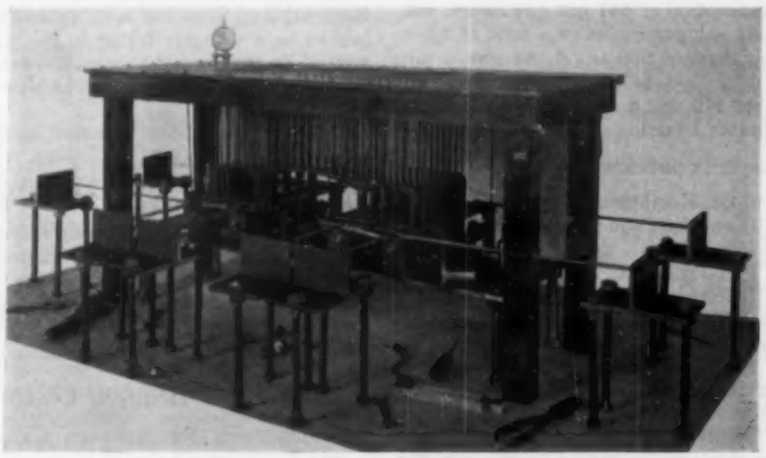
Part IV. Description of an experiment to verify the computations of Part III

Most of the mathematics are conveniently grouped in appendixes.

The practical solution of this problem marks an advanced step in the evolution of highway grade separations. The customary type of structure for the elimination of grade crossings over highways or railways has been a right-angle bridge. While this was "a step in the right direction," it did not eliminate the danger to life due to inadequate visibility and reverse curves. The skew crossing permits maintaining the alignment, or at least lengthening the line of sight, for the convenience of the motorist.

Finally, by eliminating the abutments and wing walls from the central arch and setting it on piers, the two arched approaches will permit still greater visibility. It is claimed that the cost of the end arches is practically offset by the saving due to omitting the wing wall and using smaller abutments.

In addition to a firm grasp on the theory of this subject, Professor Rathbun has an intimate knowledge of its practical applications. His ideas have been incorporated in numerous structures, with the result that the skew arch is attaining its true recognition as an architectural form of enduring beauty, a structural device of enduring strength, and an instrument for the preservation of human life.



DEVICE FOR MEASURING PIER REACTIONS OF MULTIPLE ARCH
Now at Laboratories of The College of the City of New York

RATIONAL RUN-OFF FORMULAS

To estimate the maximum storm or flood-water flow to be expected from a given drainage area is probably the first and most difficult problem encountered by engineers engaged in the design of culverts, bridges, dams, and various other structures. In their paper, R. L. Gregory and C. E. Arnold, Associate Members Am. Soc. C.E., summarize present practice in this respect and outline in detail valuable suggestions for the guidance of those who now follow the rational method of analysis. The use of empirical formulas is no longer recommended, according to the authors, although the profession owes much to the engineers who evolved them. They are the natural forerunners of the method now in use.

The rational method of estimating maximum storm-water flow may itself be divided logically into two parts. Some engineers apply what may be called the detail method and others attempt to arrive at a time of concentration for the watershed either by a comparison with tests on areas of somewhat similar characteristics or by roughly estimating the average velocity of the main channel of flow. A part of the paper is concerned with the task of showing that the detail method is not only slow and tedious but, under assumptions used at present, is erroneous. On the other hand, the authors say, that in attempting to determine average velocities for the purpose of obtaining the time of concentration by either dividing a large watershed into only a few parts or by comparing with other areas of somewhat similar characteristics, the results may be no more accurate than those obtained by means of the old empirical formulas. Because they felt that there should be a rational method of arriving at a closer approximation of the run-off from a given area by a more direct use of the several factors involved, they have evolved various useful formulas for run-off computations.

In presenting them, the authors express the hope that the paper will result in a more uniform conception of the rational method and that the inadequacy of the empirical formulas for general run-off computations will be made evident. The paper begins with a statement of the fundamental equation of run-off, that is, run-off is equal to the product of the rainfall intensity, of the area of the watershed, and of the run-off coefficient. Many uncertainties occur in the available data for the estimation of storm flow. Among these, the run-off coefficient, *c*, probably offers the widest range of differences for similar watersheds. The paper contains three basic conclusions concerning run-off coefficients and then proceeds to justify these conclusions by illustrating the application to rational assumption. The conclusions are as follows:

1. Because of an increasing wetness, which causes a higher percentage of imperviousness, the run-off coefficient for the successive individual areas composing the watershed increases with the time.

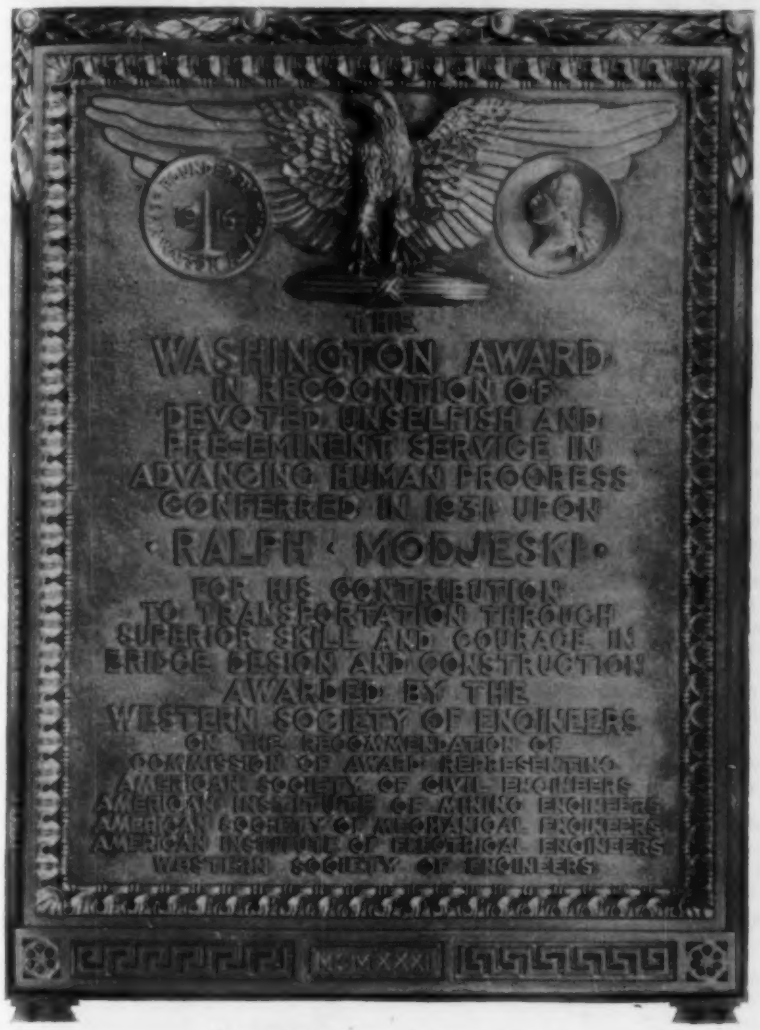
2. For the intensity decreasing with the time, the run-off coefficient for the successive individual areas composing the watershed will decrease with the time.

3. For all rainfalls of considerable uniform intensity, on any given watershed, the run-off coefficient for a rain of given intensity will be higher than that for one of less intensity, and conversely. It is assumed that the previous degree of saturation and the physical characteristics remain constant for the separate precipitations. Most of the paper deals with the actual derivation of the rainfall formulas and contains numerous examples illustrating their application to practical cases.

Having presented a general formula for the derivation of run-off, the authors proceed to illustrate its further application to special cases, including various approximations. It will be safe to say that this paper is undoubtedly one of the most complete analyses of this subject presented to the civil engineering profession in recent years. Engineers in general practice, and particularly municipal and sanitary engineers, will find much in it that will be of outstanding interest and value.

ITEMS OF INTEREST

Engineering Events in Brief



THE WASHINGTON AWARD—1931

Luigi Luiggi—An Intimate Picture

THE DEATH, on February 1, of Luigi Luiggi, Honorary Member of the Society, has already been noted He led an especially full and active life, was engaged in port and maritime work in his own and numerous other countries, and spoke and wrote fluently in French, Spanish, and English in addition to his native Italian. The following extracts from a letter received here by a friend of his family indicate the regard in which he was held.

"He had only a short illness, no pain, and was surrounded by every one close to him. He was motoring with an old Argentine friend about eleven Tuesday morning, a week ago, and had been very merry in the warm springlike day. His friend noticed he was suddenly silent and saw he had been stricken.

"The funeral was most simple—at San Agnese. There were innumerable official representatives—but all was very simple. There were no drapings or flowers. The music was marvelous—his old friend, Archbishop Guerra, had singers from the Vatican choir, and it was the most beautiful I ever heard.

"I write you all these details because I thought you would like to know that his leave-taking was really as he would have wished—in the middle of activities, for he had an appointment with Mussolini for that afternoon. He called for a paper and pencil and wrote asking that Mussolini be informed. They showed Il Duce the scrawled message and he was greatly touched. He sent a very fine telegram of condolence.

"The morning he was stricken he wrote me he had been asked to consult on the Port of Hull, England—just across from Antwerp. So he was full of hope and energy and went that way."

That he was honored and highly respected by his government is evidenced by the telegram received from Il Duce.

"I express my deep sympathy at the loss of Senator Luigi Luiggi, who was faithful to his government and constructed, even in other countries, works which have honored Italian genius and industry. Mussolini"

Many other expressions of sympathy showed the high esteem in which he was held by his countrymen and by friends in other nations.

Rock Tunnel Methods

AN EXCELLENT volume has just been released by *The Explosives Engineer*, of Wilmington, Del. It is entitled *Rock Tunnel Methods* and is a compilation of data on 31 recently constructed large railroad, mine, water-supply, and hydroelectric tunnels. These data are complete and authoritative, and the volume is gratis upon request. It is a very useful symposium on the subject and should be of considerable interest to tunnel builders. In addition to the symposium, the volume contains indexes and some helpful notes on the handling of explosives.

COMING EVENTS

NORFOLK IS NEXT!

Spring Meeting of the American Society of Civil Engineers

Convenes in Norfolk, Va.

April 15, 16, 17, 1931

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
- District meeting at Rochester, April 29–May 2

AMERICAN SOCIETY OF MECHANICAL ENGINEERS
- Semi-annual meeting in Birmingham, Ala., April 20–23

AMERICAN WATER WORKS ASSOCIATION
- Illinois section, annual meeting in Bloomington, Ill., April 23–29
- Montana section, annual meeting in Helena, Mont., April 9–10
- New York section, annual meeting in Troy, N.Y., April 22, 23
- Southeastern section, annual meeting in Columbia, S.C., April 7–9

New Standards Data

A NEW compilation of data entitled *Measurement Units and Standards,* has just been issued by the American Institute of Weights and Measures, 33 Rector Street, New York. A letter addressed to the Secretary of the Institute will bring a free copy of this book. It contains many data useful to those who deal with nomenclature for standards and units.

False Pretenses

CLAIMING TO BE a graduate of the University of Toronto and an engineer, a young man has represented himself as either a son, nephew, or close acquaintance of at least two well known members of the profession and of the Society in Toronto and New York, and has successfully cashed worthless checks on various banks in Toronto, Montreal, Boston, New York, and Chicago.

He is described as being about 28 years old, thin, clean shaven, fair complexioned, with dark brown hair and a high forehead, about 5 ft. 11 in. tall, well dressed, a very fluent talker, but of deliberate and pleasing manner. The names he has used are Millard, Mallard, Kingsbury, and Thomson. Members are warned against the operations of this man and are asked to assist in apprehending him by sending full information at once to Society Headquarters. He was last heard of in Chicago. A warrant has been issued for him by the Toronto police.

American Arbitration Association

AN ARBITRATION ACT based on the draft prepared by the American Arbitration Association and endorsed by the Society has been introduced in the state legislatures of Colorado, Montana, Ohio, and Texas. In Oregon the present law is being amended to conform to the Draft State Arbitration Act. Any members who are interested in securing the passage of the act in the states mentioned should communicate with the American Arbitration Association, 521 Fifth Avenue, New York.

NEWS OF ENGINEERS

GUSTAVUS A. GESSNER is President and Treasurer of the Northland Construction Company of Toledo, Ohio.

JOHN R. ELLIS has recently changed his position from Coordination Engineer for the San Fernando Valley Rock and Sand Association of Glendale, Calif., to Engineer of Special Assignment for the Missouri State Highway Department in Jefferson, Mo.

SIDNEY FRIEMAN, at one time associated with the Ball and Snyder Company of New York, has become an Engineer for the Chanin Construction Company.

OTTO LAUTERHAHN has the position of Associate Engineer for the U.S. Geological Survey, with headquarters in Trenton, N.J.

FRED E. HALE, who was Assistant Designing Engineer of the Alabama Power Company, is now Engineer in Charge of Design and Drafting for the Allied Engineers, Inc., of Birmingham, Ala.

ALEXANDER N. MILLER has resigned from his position as Mechanical Engineer for the Mine and Smelter Supply Company of Great Falls, Mont., and is at present associated with the Anaconda Copper Mining Company as Civil and Mechanical Engineer.

CAREY H. BROWN, of Rochester, N.Y., has accepted an appointment as Executive Director of the Rochester Civic Improvement Association.

WILLIAM H. REEVES is now in Coahuila, Mex., where he is Secretary and Treasurer of the International Water Company of Mexico. He was previously Secretary and Treasurer of the Layne Bowler Company of Chicago, Ill.

ROBERT F. MOSS, former Vice-President of the Truscon Steel Company of Japan, is now President of the Japan Steel Products Company in Tokyo.

REUBEN S. PROTTER is President of the Wisconsin Equities, Inc., of Milwaukee Wis. He was formerly Vice-President of the Second Ward Savings Bank of Milwaukee.

JAMES H. DOWLING, who was at one time Divisional Engineer for the State Road Department of Lake City, Fla., is at present Lime Rock Engineer for the Georgia Highway Department of Valdosta, Ga.

WILLIAM J. RINEBOLD is with the Port of New York Authority as Assistant Engineer.

CORNELIUS P. HARNISH has become Chief Engineer for the American States Water Service Company of California, being situated in Los Angeles.

ERNEST D. MORTENSON, who has been a Construction Engineer with Lawson W. Oakes of Boston, Mass., has accepted a similar position with Thompson's Spa, Inc.

George T. MACNAB has recently accepted the position of Southern Highway Engineer in the Department of Agriculture, Federal Government, Raleigh, N.C.

HARRY P. HART is now the Northwest Representative of the Pomona Pump Company of Seattle. He was formerly Chief Engineer of the Thompson Manufacturing Company, of Los Angeles.

CONRAD O. MANNES, one-time Superintendent of the S.A. Moceri Company, Inc., Seattle, Wash., is at the present date a member of the firm of Mannes and Trester, General Contractors, also located in Seattle.

BERNHARD RASMUSSEN has been appointed Assistant Engineer in the Department of Water, Gas, and Electricity of the City of New York.

GEORGE C. GRAETER is Vice-President and General Manager of the Richmond Sand and Gravel Corporation, Richmond, Va.

CHARLES A. MULLEN has recently become Consulting Paving Engineer for the Director of Paving Department of the Milton Hersey Company, Ltd., of Montreal.

H. RAY KINGSLEY, who was Resident Engineer for Lockwood Green Engineers, Inc., in New York City, has accepted the position of Associate Engineer, Structural Division, Supervising Architect, Treasury Building, Washington, D.C.

T. FRANK QUILTY, who in the past has been President of the Superior Stone Company and Quality Construction Company of Chicago, is now President of the Superior Material Company, and Vice-President of the Moulding Brownell Corporation.

CHARLES R. MOORE is at present Division Manager of the Washington Water Power Company at Oakanogan, Wash.

EDWARD D. CLEMENT, President of the Salmons-Clement Company, is now President of the Clement Construction Company in Charleston, S.C.

TOSHIYUHI OKUBO, formerly connected with the Truscon Steel Company of Japan, has now become associated with the Japan Steel Products Company at Tokyo.

HAROLD E. HILTS, who was Vice-President of the Cuban Portland Cement Corporation at Havana, Cuba, is now Vice-President and Manager of the Lone Star Cement Company in Philadelphia, Pa.

EUGENE H. SCHNEIDER has resigned as Designing Engineer for the Herbert S. Crocker Company in Denver, Col., and has accepted the position of Special Engineer in Charge of Design on the Moffat Water Tunnel for the Denver Municipal Water Commission.

ARTHUR A. STILES is with the Austin, Texas, Branch of the Pure Oil Company as Cadastral Engineer.

JEREMIAH TEMPONE, formerly a Designing Engineering for United Engineers and Constructors, Inc., in Philadelphia, is now President of the American Steel Construction Company.

IREAL A. WINTER has become associated with Allied Engineers, Inc., in Birmingham, Ala., as Hydraulic Engineer. Heretofore, he has been connected with the Alabama Power Company.

GEORGE V. SALLE, who was District Manager for the Foundation Company in New York City, is now Vice-President of the H. J. Deutschebin Company, Inc., also in New York.

Allen Van Rensselaer is a member of the firm of Van Rensselaer and Isham, Engineers and Contractors, at Los Angeles, Calif.

William C. Cram, Jr., who has been Manager of the Empire Construction Company in Atlanta, Ga., is at present District Manager of the Allied Engineers, Inc., in the same city.

Jonathan G. Wright, a former Assistant Engineer for Henry D. Dewell of San Francisco, Calif., has become a Structural Engineer for the Standard Oil Company of California.

Lathrop C. Pope is at present associated with the Carleton Company, Inc., Brooklyn, N.Y., as Resident Engineer. Formerly, he was connected with the Oakdale Contracting Company, New York City.

Henry R. Walters, who was with the Bethlehem Steel Company, has recently been appointed Assistant to the President of the McClintic-Marshall Corporation at Bethlemem, Pa.

Theodore Grahlman is an Assistant Engineer with the Port of New York Authority.

John P. Wagstaff, one-time Structural Designer for the firm of Voorhees, Gmelin and Walker, New York City, has accepted a position in the same capacity, with Fellheimer and Wagner, also of New York City.

John C. Balcomb has become connected with the Allied Engineers, Inc., New York City. Prior to that, he was Engineer in Charge for Stevens and Wood, Inc., on the Spier Falls Hydro Development at Glens Falls, N.Y.

J. Haworth Eaton has left the New England Power Company and is now Associate Structural Engineer in the Office of the Supervising Architect, Treasury Department, Washington, D.C.

William H. Overshiner, formerly Assistant Engineer for the W. W. Hay Company of Santa Ana, Calif., has transferred to the Orange County Flood Control District.

Floyd S. Oldt has accepted the position of Superintendent of Construction, with the Dallas Transportation Company, having previously held a similar position with the Rollen J. Windrow Company.

Hugh K. Hood is at present with Jensen, Bowen and Farrell, Ann Arbor, Mich.

Troy D. Holloway has become connected with the Division of Highways at Springfield, Ill., as Junior Highway Engineer.

Arthur R. Eitzen, who was Structural Designer for the Sanitary District of Chicago, is now in the Bridge Department of the Chicago and Northwestern Railway, Chicago, Ill.

Robert Coltman, Jr., formerly with the Charles B. Hawley Engineering Corporation, has accepted the position of Structural Engineer in the Construction Quartermaster's Office, War Department, Washington, D.C.

Ross E. Wilson has left the Firestone Tire and Rubber Company and is now Appraisal Engineer for the Virginia Public Service Company.

John W. Fenton is Superintendent of Construction for the United Engineers and Constructors, Inc., in New Jersey.

Lee G. Warren is General Superintendent of Construction for the Phoenix Utility Company, which is at work on Carpenter Dam for the Arkansas Power and Light Company, near Hot Springs, Ark.

Wilmot E. Whittier has accepted a position as Engineer for the Metropolitan Water District of Southern California.

Anton Skrede, formerly Designer for the U.S. Gypsum Company, is now connected with the John S. Metcalf Company, of Chicago, in the same capacity.

William Bryant Bennett, who was with the St. Louis Public Service Company, is now Special Engineer for the Washington Railway and Electric Company, Washington, D.C.

Walter S. St. John, who was at one time with the H. G. Balcom Company, is at present Assistant Engineer for the New York Central Railroad Company.

George S. Wells is a Civil Engineer for the Burmah Oil Company, Ltd., in India.

Robert S. Treat, connected at one time with the Berlin Construction Company, has become associated, as Draftsman in the Bridge Division, with the Connecticut Highway Department.

Daniel B. Ventres, formerly District Engineer for Travaux Publics, Haiti, is now with the Plant Department, Boston, Mass.

Jacob L. Crane, Jr., of Chicago, has left to attend the International City Planning Congress in Berlin. Enroute, he will stop at Canton, China, and Moscow, Russia, to do some consultation work for which he has been retained.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From February 10 to March 9, 1931

Additions to Membership

Africa, Charles McKnight. (Assoc. M., Feb. '31.) Chf., Field Parties, Pennsylvania Water & Power Co., Glencoe, Md.

Anderson Irvin Elmer. (Jun., Jan. '31.) Junior Engr., U.S. Geological Survey, Tuscaloosa, Ala.

Applebaum, Leon Benedict. (Jun., Feb. '31.) Eng. Asst., Board of Transportation, New York, N.Y.

Bailey, Thomas Samuel. (Jun., Oct. '30.) 518 South 4th St., West, Cedar Rapids, Iowa.

Barber, Clifton Abel. (Jun., Dec. '30.) Eng. Dept., New York Telephone Co., Poughkeepsie, N.Y.

Biberstein, Frank Aloysius, Jr. (Assoc. M., Feb. '31.) Dean, Eng. Dept., Columbia School of Drafting and Eng., Washington, D.C.

Birdsall, Blair. (Jun., Jan. '31.) Asst. Insp., Bldg. Constr., Voorhees, Gmelin & Walker, New York, N.Y.

Borland, Whitney McNair. (Jun., Feb. '31.) 202 West Olive St., Fort Collins, Colo.

Bradfield, Stephen Arthur. (Jun., Oct. '30.) 1550 Broadway, Boulder, Colo.

Brogden, Vernon Singerland. (Assoc. M., Feb. '31.) Res. Engr., Klyce & Harrub, Nashville, Tenn.

Brosell, Edward Solfrid. (Jun., Feb. '31.) Draftsman, Ambursen Constr. Co., 2518 Grand Central Terminal Bldg., New York, N.Y.

Bruck, Henry Hans. (Jun., Nov. '30.) Insp. and Engr., R. W. Hunt Co., 251 Kearny St., San Francisco, Calif.

Burgess, Eric Turner. (Jun., Dec. '30.) 598 Pine St., Ambridge, Pa.

Bussard, Marcel Julian. (Assoc. M., Jan. '31.) Engr., U.S. Dept. of State, Box 1065, Balboa, Canal Zone.

Carrillo, Edward John. (M., Feb. '31.) Chf. Engr., Ft. Tryon Park for Olmsted Brothers, 799 Ft. Washington Ave., New York, N.Y.

Challenger, Albert Edwin. (Assoc. M., Feb. '31.) Asst. Engr., Quinton, Code, Hill-Leeds & Barnard, Engrs., Consolidated, Los Angeles, Calif.

Cherry, James Henry. (Assoc. M., Feb. '31.) Concrete Engr., International Cement Corporation, 1120 Hibernia Bank Bldg., New Orleans, La.

Clark, Max. (Jun., Oct. '30.) 40 Elmer St., Hartford, Conn.

Cline, Frederick. (Jun., Nov. '30.) Hydrographer, Dept. of Water and Power, Los Angeles, Calif.

Collier, Theodore Franklin. (Assoc. M., Oct. '30.) Engr. in Chg., Reinforced Bar Dept., Capitol Steel & Iron Co., Oklahoma City, Okla.

Conroy, Grover Francis. (M., Aug. '30.) Engr., Southwestern Portland Cement Co., El Paso, Tex.

Daniggelis, John Nicholas. (Jun., Oct. '30.) 1720 Sedgwick St., Chicago, Ill.

Deane, William Francis. (Jun., Oct. '30.) U.S.S. Natoma, Savannah, Ga.

DeGeurin, Lewis Claudius. (Jun., Aug. '30.) Structural Engr., Phoenix, Ariz.

Disbrow, William Cook, Jr. (Assoc. M., Feb. '31.) Sales Engr., Wemlinger, Inc., Tampa, Fla.

DOWNEY, WILLIAM NELSON. (Assoc. M., Jan. '31.) Care, Cincinnati Union Terminal Co., 1020 Temple Bar Bldg., Cincinnati, Ohio.

DRISCOLL, ROBERT JOSEPH. (Jun., Jan. '31.) Goulds Pumps, Inc., Seneca Falls, N.Y.

ENGLE, GLENN FRANKLIN. (Assoc. M., Jan.'31.) Supervisor of Dams, State of California, Sacramento, Calif.

EPSTEIN, NATHAN. (Assoc. M., Dec. '30.) Corson Constr. Corporation, 319 Lafayette St., New York, N.Y.

FALCO, MACEO. (Assoc. M., Feb. '31.) Insp., Arlington Memorial Bridge Comm., Washington, D.C.

FINN, PHILIP SUDER, JR. (Jun., Feb. '31.) Care, U.S. Engrs., Mound, La.

FRENCH, BAIRD MILLER. (Jun., Jan. '31.) Junior Highway Engr., U.S. Bureau of Public Roads, Box 781, Juneau, Alaska.

GABBE, HENRY WALTER. (Jun., Feb. '31.) George Cherr, Inc., 189 Joralemon St., Brooklyn, N.Y.

GARCIA, JOE, JR. (Jun., Feb. '31.) Deputy County Engr., Tulare County, 449 South Church St., Visalia, Calif.

GREBE, KARL ANDREW. (Jun., Oct. '30.) Student Engr., Lehigh Structural Steel Co., Allentown, Pa.

GREY, HOWARD. (Jun., Feb. '31.) Draftsman, Morris Knowles, Inc., 507 Westinghouse Bldg., Pittsburgh, Pa.

HECKATHORN, JOHN HENRY. (Jun., Oct. '30.) 1103 Hays, Boise, Idaho.

HICKS, EDGAR FLANOY, JR. (Jun., Nov. '30.) Care, U.S. Coast & Geodetic Survey, Washington, D.C.

HOFFMAN, EDWARD BURNETT. (Jun., Feb. '31.) Draftsman-Detailer, Reading R.R., Philadelphia, Pa.

HOLLAND, JOHN GILLESPIE. (Jun., Nov. '30.) 212 Methvin St., Longview, Tex.

HOLLENDER, EDMUND, JR. (Jun., Dec. '30.) 2034 East 28th St., Brooklyn, N.Y.

JONES, ARTHUR NORMAN, JR. (Jun., Nov. '30.) 603 Denise Rd., Rochester, N.Y.

KAPPE, STANLEY EDWARD. (Jun., Jan. '31.) San. Officer, State Dept. of Health, Philadelphia, Pa.

KEELING, ROSS CURTIS. (Assoc. M., Jan. '31.) Div. Engr., State Highway Comm., Norton, Kans.

KUAN FU CHUAN. (Jun., Feb. '31.) 203 Linden Ave., Ithaca, N.Y.

LIU, CHIEN-HSI. (Jun., Feb. '31.) 413 Mitchell St., Ithaca, N.Y.

LYNN, CHARLES FERGUSON. (Jun., Oct. '30.) 2018 Gadsden St., Columbia, S.C.

MCKAY, ELMER CHRISTIE. (Assoc. M., Feb. '31.) Mathematician, U.S. Coast & Geodetic Survey, Washington, D.C.

MCLEAN, RALPH STEWART. (Jun., Nov. '30.) 306 South Catalina, Pasadena, Calif.

MAGEE, BRONSON ROY. (Assoc. M., Oct. '30.) Engr., Bldg. Const. Div., Arthur G. McKee & Co., 242 Euclid Ave., Cleveland, Ohio.

MAJOR, SAMUEL ROBERTSON. (Jun., Oct. '30.) Engr., Sun Oil Co., Marcus Hook, Pa.

MONAGHAN, JOHN CHARLES. (Jun., Feb. '31.) Estimator, Div. of Water Resources, State Dept. of Public Works, Sacramento, Calif.

MUNZ, OLIVER WESLEY. (Jun., Oct. 30.) 2419 North 39th St., Milwaukee, Wis.

MURER, ELDRED BEVERLY. (Jun., Nov. '30.) 959 Seventeenth Ave., S.E., Minneapolis, Minn.

MURRAY, RAYMOND HENRY NEWTON. (Jun., Nov. '30.) 302 Zara St., Pittsburgh, Pa.

MYHAND, WILLIAM HENRY. (Assoc. M., Nov. '30.) Asst. Dist. Maintenance Supt., State Highway Comm., Arcadia, La.

NEWCOMB, JOHN LLOYD. (M., Feb. 31.) Dean, Dept. of Eng., Univ. of Virginia, Box 36, University, Va.

NOON, EDWARD MENZEL. (Assoc. M., Feb. '31.) Care, F. K. Berringer, 1072 Woodycrest Ave., Apartment 1-E, New York, N.Y.

NORTON, IRWIN GILBERT. (Assoc. M., Jan. '31.) Associate Engr., Walter F. Schulz, 870 Shrine Bldg., Memphis, Tenn.

NUSSBAUMER, NEWELL LOUIS. (Assoc. M., Feb. '31.) Engr., George C. Diehl, Inc., 577 Ellicott Sq., Buffalo, N.Y.

O'DEA, JOSEPH CYRIL. (Assoc. M., Feb. '31.) Engr. in Chg., Div. of Survey and Design, Bureau of Highways, Brooklyn, N.Y.

PACKER, ELMER WILLARD. (Assoc. M., Feb., 31.). Res. Highway Engr., Southern Div., State Highway Dept., 217 Guilford Ave., Collingswood, N.J.

PEOT, WERNER ANTHONY. (Jun., Feb. '31.) Draftsman, Sewerage Comm., City of Milwaukee, Milwaukee, Wis.

PERKINS, STANLEY NEWHALL. (Jun., Oct. '30.) 306 Spring St., Elgin, Ill.

PERRY, WILDUR DOW. (Jun., Feb. 31.) Drainage Engr., Western Metal Mfg. Co., Dallas, Tex.

PLÁ, GABRIEL. (Assoc. M., Aug. '30.) Box G, Marina Station, Mayagüez, Porto Rico.

RIDER, JANE HERBST. (Assoc. M., Feb. '31.) Director, Arizona State Laboratory, Tucson, Ariz.

ROGERS, HARVEY GRIFFIN. (Assoc. M., Feb. '31.) San. Engr., State Board of Health, Div. of Sanitation, Minneapolis, Minn.

RUST, JOHN ANDREW. (Jun., Jan. '31.) Student Apprentice, So. Ry., 105 Saluda St., Chester, S.C.

SAUNDERS, JOHN LAROY. (Assoc. M., Jan. '31.) Asst. Engr., Surface Water Branch, U.S. Geological Survey, P. O. Bldg., Tuscaloosa, Ala.

SCHEDER, WILLIAM SYLVESTER. (Assoc. M., Feb. '31.) Structural Engr., 435 North Front St., Baltimore, Md.

SHIELDS, KEITH ANSON. (Jun., Oct. '30.) 334 Glenwood Rd., Ambridge, Pa.

SHIELDS, KENNETH EVELAND. (Jun., Oct. '30.) 334 Glenwood Rd., Ambridge, Pa.

SHUBS, MAX ARNOLD. (Jun., Oct. '30.) 44 Hurlburt St., New Haven, Conn.

SIESEL, SIDNEY MONTEFIORE. (M., Feb. '31.) Pres. and Gen. Mgr., S. M. Siesel Co., 514 East Ogden Ave., Milwaukee, Wis.

SIJAN, AHMED MUKHTAR. (Jun., Feb. '31.) 222 University Ave., Ithaca, N.Y.

SINGH, LAL. (Jun., Nov. '30.) The Empire Foundry, Rangoon, Burma, India.

SMITH, ROBERT NICHOLAS. (Jun., Oct. '30.) Care U.S. Engr. Office, Savannah, Ga.

STONE, JAMES ALLAN. (Jun., Nov. '30.) Roofing Foreman, The Barrett Co., Chicago, Ill.

STRATTON, ROBERT HASTINGS, JR. (Jun., Oct. '30.) 1001 North Stoneman Ave., Alhambra, Calif.

SYLVESTER, BOYD EDWARD. (Assoc. M., Feb. '31.) Chf. Draftsman, State Highway Comm., Dist. IX, Box 111, Bishop, Calif.

TARBOX, GEORGE EDWARD, JR. (Jun., Feb '31.) Branch Mgr., Keystone Driller Co., Birmingham, Ala.

TEAGUE, ANDREW LAWRENCE. (Jun., Feb. '31.) Draftsman, Bridge Dept., State Highway Comm., Oklahoma City, Okla.

TORKELSON, FRANCIS ARTHUR. (Assoc. M., Feb. '31.) City Engr., Wauwatosa, Wis.

UPDYKE, GERALD AUSTIN. (Jun., Oct. '30.) Am. Bridge Co., Ambridge, Pa.

VOLLMER, VICTOR ALLEN. (Assoc. M., Feb. '31.) Structural Engr. and Chf. Draftsman, Fletcher-Thompson, Inc., Bridgeport, Conn.

WACHTER, FRANK CLEMENT. (Jun., Feb. '31.) Designer, Henry G. Perring, Baltimore, Md.

WALKER, JOHN FRAME. (Assoc. M., Oct. '30.) Asst. Engr., Ayres, Lewis, Norris & May, Ann Arbor, Mich.

WALSH, THEODORE MICHAEL. (Jun., Feb. '31.) County Surv., 700 Hall of Records, Los Angeles, Calif.

WEIRICH, ALFRED FRANKLIN. (Jun., Jan. '31.) Draftsman, Proctor & Gamble Co., Ivorydale, Cincinnati, Ohio.

WHITE, IVAN FORREST. (Assoc. M., Oct. '30.) Dist. Engr., Bureau of Eng., Los Angeles, Calif.

WOLF, CLEMENS WILLIAM HENRY. (Jun., Feb. '31.) Designer, Fargo Eng. Co., 120 Michigan Ave., West, Jackson, Mich.

ZEISLER, GEORGE H. (M., Feb. '31.) Engr., Henry W. Horst Co., Philadelphia, Pa.

MEMBERSHIP TRANSFERS

BEAUREGARD, ARMAND TOUTANT. (Jun., '25; Assoc. M., Feb. '31.) 280 Glenwood Ave., Bridgeport, Conn.

BRITTON, CLARK VEAZIE. (Jun., '27; Assoc. M., Feb. '31.) Superv. Engr., Air Reduction Sales Co., 60 East 42d St., New York, N.Y.

BROOKS, ERNEST RAMSDEN. (Jun., '25; Assoc. M., Feb. '31.) First Asst. Surv., Dept. of Public Works, Bureau of Eng. and Surveys, 3017 F. St., Philadelphia, Pa.

CARPENTER, CARL BRADFORD. (Jun., '28; Assoc. M., Feb. '31.) City Engr., Bloomington, Ind.

COLLINS, JAMES BERNARD. (Jun., '27; Assoc. M., Feb. '31.) Junior Engr., Port of New York Authority, New York, N.Y.

COOMBS, DONALD GLADSTONE. (Jun., '16; Assoc. M., '19; M., Feb. '31). Operating Mgr., Shell Eastern Petroleum Products, Inc., 122 East 42d St., New York, N.Y.

COSTELLO, EDWARD JAMES, JR. (Jun., '22; Assoc. M., Feb. '31.) 160 South Park Ave., Wheeling, W.Va.

CUTLER, ALVIN SAYLES. (Assoc. M., '10; M., Feb. '31.) Prof., Railway Eng., Coll. Eng. and Architecture, Univ. of Minnesota, Minneapolis, Minn.

DARBY, EUGENE BENJAMIN. (Jun., '20; Assoc. M., Feb. '31.) Supt., R. W. Briggs & Co., Pharr, Tex.

DEBLOIS, KENNETH LEWIS. (Jun., '23; Assoc. M., Jan. '31.) Asst. Engr., C.C.C. & St.L.Ry., Cincinnati, Ohio.

DYSINGER, MYRON ALLEN. (Jun., '27; Assoc. M., Feb. '31.) Voorhees, Gmelin & Walker, 370 Lexington Ave., New York, N.Y.

ENGSTROM, WALLACE RICHARD. (Jun., '26; Assoc. M., Jan. '31.) Project Engr., The Austin Co., 877 Dexter-Horton Bldg., Seattle, Wash.

EWALD, ROBERT FRANKLIN. (Assoc. M., '11; M., Feb. '31.) Hydr. Engr., Aluminum Co. of America, 2400 Oliver Bldg., Pittsburgh, Pa.

GOVIN, GUSTAVO LAWRENCE. (Assoc. M., '25; M., Jan. '31.) 1229 Park Ave., Hoboken, N.J.

HARRIS, HOWARD AVERY, JR. (Jun., '29; Assoc. M., Oct. '30.) Asst. Chf. Engr., Public Works Eng. Corporation, San Francisco, Calif.

HOPKINS, JOHN WILLIAM. (Jun., '29; Assoc. M., Feb. '31.) Bridge Designer, A, Bridge Div., State Dept. of Highways, Harrisburg, Pa.

KELLERMANN, WILLIAM FRANCIS. (Jun., '28; Assoc. M., Jan. '31.) Asst. Materials Eng. U.S. Bureau of Public Roads, 515 Fourteenth St., Washington, D.C.

KERANEN, JOHN ELMER. (Jun., '26; Assoc. M., '31.) Structural Engr., The Corn Products Refining Co., 333 North Michigan Ave., Chicago, Ill.

KOSTING, FREDERICK WILLIAM. (Jun., '24; Assoc. M., Feb. '31.) Structural Engr., Gulf Refining Co., Constr. Dept., 21 State St., Room 605, New York, N.Y.

LILIEN, FRANK. (Jun., '22; Assoc. M., Feb. '31.) Asst. Engr. to Pres., Borough of Queens, Borough Hall, Long Island City, N.Y.

MCNICHOLAS, RICHARD. (Jun., '28; Assoc. M., Feb. '31.) Kenneth Markwell & Associates, Memphis, Tenn.

MAUGH, LAWRENCE CARNAHAN. (Jun., '26; Assoc. M., '31.) Instr., Civ. Eng., Univ. of Michigan, 301 West Eng. Bldg., Univ. of Michigan, Ann Arbor, Mich.

OVENSHINE, EUGENE SAMUEL. (Jun., '29; Assoc. M., '31.) Dwight P. Robinson & Co., Inc., 125 East 46th St., New York, N.Y.

RICHMOND, ALLEN PIERCE, JR. (Jun., '16; Assoc. M., '24; M., Feb. '31.) Asst. to Secy., Am. Soc. C.E., 33 West 39th St., New York, N.Y.

SEASHORE, PAUL THEODORE. (Jun., '24; Assoc. M., Feb. '31.) Vice-Pres., The Louisiana Land & Exploration Co., 1703 Esperson Bldg., Houston, Tex.

SIMON, PAUL. (Jun., '20; Assoc. M., Oct. '30.) Sundtoldgaarden, Elsinore, Denmark.

SUKHUM, PRASOB. (Jun., '24; Assoc. M., Nov. '30.) Engr., City of Bangkok, City Engr.'s Office, Bangkok, Siam.

SYLLIAASEN, MELVIN OLIVER. (Jun., '14; Assoc. M., '19; M., Feb. '31.) Chf. Structural Engr., John Graham, Seattle, Wash.

THOMAS, WESTON GAGE. (Jun., '27; Assoc. M., Feb. '31.) Care, Lehman Corporation, 1 South William St., New York, N.Y.

Trahern, James William. (Jun., '28; Assoc. M., Jan. '31.) Designing Engr., East Bay Municipal Utility Dist., Box 458, Oakland, Calif.

Vaughn, Romney Leigh. (Jun., '12; Assoc. M., '18; M., Jan. '31.) Cons. Engr., 526 Sheldon Bldg., San Francisco, Calif.

Ward, Joseph Augustus. (Assoc. M., '23, M., Feb. '31.) Senior Asst. Engr., North Jersey Dist. Water Supply Comm., Sunset Rd., Pompton Plains, N.J.

White, Russell Grant. (Jun., '26; Assoc. M., Feb. '31.) Asst. Highway Engr., Bexar County, San Antonio, Tex.

Reinstatements

Frost, Lloyd Garner, Assoc. M., reinstated Feb. '31.

Holmes, Howard Whittier, M., reinstated Feb. '31.

Sparrow, William Warburton Knox, M., reinstated Feb. '31.

Resignations

Beeson, Alexander Conn, M., resigned Feb. '31.

Insley, William Henry, M., resigned Feb. '31.

Loftin, Haroldb Turner, Jun., resigned Feb. '31.

Russell, George Raymond, M., resigned Mar. '31.

Scheirer, Merrill Kleckner, Assoc. M., resigned Feb. '31.

Shippey, Kelley Ford, Jun., resigned Feb. '31.

Voynow, Constantine Borisson, M., resigned Feb. '31.

Deaths

Bergendahl, Gustav Storm. Elected M., Apr. 1, 1914; died Feb. 25, 1931.

Crooks, Clinton Hervey. Elected Jun., Oct. 3, 1905; Assoc. M., Sept. 5, 1911; died Feb. 11, 1931.

Detwiler, Harry Espenship. Elected M., Oct. 14, 1929; died Feb. 19, 1931.

Easterbrooks, Preston Burt. Elected Assoc. M., May 1, 1907; died Feb. 1, 1931.

Emerson, Frank Collins. Elected M., May 13, 1918; died Feb. 19, 1931.

Fitzgerald, William Edward. Elected Jun., May 31, 1916; Assoc. M., Apr. 14, 1919; died Feb. 9, 1931.

Gagel, Edward. Elected M., Apr. 3, 1907; died Feb. 11, 1931.

Gates, Horace Delphos. Elected M., Mar. 7, 1883; died Jan. 8, 1931.

Griggs, Ernest Lee. Elected M., Nov. 15, 1926; died Feb. 25, 1931.

Hallett, James Hendricks. Elected Assoc. M., June 23, 1916; died Jan. 11, 1931.

Jadwin, Edgar. Elected M., Apr. 20, 1925; died Mar. 2, 1931.

Kondo, Sentaro. Elected M., Nov. 7., 1900; date of death unknown.

Lundie, John. Elected M., July 4, 1888; died Feb. 9, 1931.

McGrew, Anson Burlingame. Elected M., June 4, 1902; died Feb. 26, 1931.

Manson, Marsden. Elected M., Sept. 6, 1882; died Feb. 21, 1931.

Minor, Sheldon Elton. Elected M., June 3, 1915; died Feb. 19, 1931.

Montfort, Richard. Elected M., June 6, 1888; died Feb. 7. 1931.

Randolph, William Couts, Jr. Elected Assoc. M., June 9, 1930; died Jan. 17. 1931.

Shepley, Charles Rogers. Elected M., Dec. 31, 1913; died Feb. 9, 1931.

Starr, Herbert Harris. Elected Assoc. M., Oct. 1907; died Feb. 18, 1931.

Stone, William Greene. Elected Affiliate Dec. 2, 1914; died Feb. 12, 1931.

TOTAL MEMBERSHIP AS OF MARCH 9, 1931

Members	5,825
Associate Members	6,238
Corporate Members	12,063
Honorary Members	16
Juniors	2,626
Affiliates	133
Fellows	7
Total	14,845

Men and Positions Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fees is to be found on page 97 of the 1931 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Men Available

Civil Engineer; Jun. Am. Soc. C.E.; 30; married; good draftsman and letterer; 3 years experience as structural draftsman and checker on steel and reinforced concrete construction; 2 years topographical draftsman; desires position in New York City. C-4281.

Civil Engineer; Jun. Am. Soc. C.E.; 31; single; graduate Purdue University, 1926. Five years experience in research work, on portland cement and concrete in laboratories of Portland Cement Association and Johns-Manville Corporation. Excellent references from present and former employers. Desires location in vicinity of New York City, but will go anywhere. Available about March 1. C-8698.

Construction and Structural Engineer; M. Am. Soc. C.E.; single. Illinois State License. World-wide experience on large projects in Europe, Australia, and North America. American citizen. Twenty years responsible charge with contractors, consulting engineers, and architects. Best references. Knowledge three languages. Desires position with American firm abroad. C-8786.

Construction Engineer or Superintendent; M. Am. Soc. C.E.; 52; married; 10 years railroad construction in Western United States; 8 years in South America on hydro-electric, tunnel, and building work; 4 years in New York on sewer construction; $5^1/_2$ years on steam power station construction in Ohio and New Jersey; $1^1/_2$ years on hydro-electric work in New York State; speaks Spanish, Portuguese; will go anywhere. B-1340.

Graduate Engineer; M. Am. Soc. C.E.; licensed in New York and New Jersey; married; experienced in structural design, construction of plants, buildings, bridges, municipal work, steam boilers, estimates, and reports. Desires position as office engineer or assistant in New York or vicinity. Moderate salary. B-3452.

Estimator; Jun. Am. Soc. C.E.; 29; civil engineering graduate; 6 years experience in general contractor's office; estimating all types of commercial, industrial, and public buildings; cooperating with superintendents in field; preparing drawings and details requiring engineering skill and knowledge; expediting sub-contracts. Capable of responsible charge in office or field. Excellent references. C-1.

Civil Engineer; M. Am. Soc. C.E.; age 42; experience includes supervising and directing engineering and construction in hydro-electric studies and investigations, clearing of reservoirs, malarial control methods, water works, gas plants, street railways, location of transmission lines, extensive topographic surveys, hydrographic surveys, specifications, estimates, and reports. C-8754.

Consulting Engineer; M. Am. Soc. C.E.; graduate engineer; American; wide experience in connection with various industries, particularly the manufacture and fabrication of steel; desires a connection with a large bank or financial institution as technical adviser; member of various national engineering societies; large acquaintance. Qualified to report on different industries. C-7790.

Civil Engineer; Jun. Am. Soc. C.E.; age 25; married; graduate in civil engineering, Georgia School of Technology; 3 years experience in the design of state highways. Desires position as designer or draftsman with large construction company or consulting engineer in South. Position must be permanent. Available short notice. C-8821.

Civil Engineer; Jun. Am. Soc. C.E.; graduate Rensselaer Polytechnic Institute; $5^1/_2$ years experience (1 year in the employ of prominent consulting engineer); designing and drafting structural steel, timber, and concrete. Desires position as designer or assistant engineer. C-140.

Sanitary Engineer and Construction Superintendent; Assoc. M. Am. Soc. C.E.; age 31; married; university graduate; licensed professional engineer; 8 years experience (2 years complete charge on sewer construction, sewage disposal, and compressed air caisson work); construction and purchasing. Available on short notice anywhere in North America. C-8845.

Civil Engineer; Jun. Am. Soc. C.E.; age 24; university graduate, 1929; $1^1/_2$ years field work with prominent construction company, specializing in reinforced concrete; knowledge of cost accounting; summer experience in city and railroad surveying; desires work with construction company or consultant; location unessential. C-5900.

Construction and Designing Engineer; age 39; married; college graduate; over 19 years experience on industrial plants, tipples, headframes, bins, conveyors, coal mining structures, power houses, boiler houses, copper mining and smelting plants, difficult underpinnings, subway construction, and general building work. Would go abroad. C-8810.

Estimator and Structural Engineer; Assoc. M. Am. Soc. C.E.; graduate, Massachusetts Institute of Technology; 35; married. Desires position with construction or engineering concern, United States or abroad. Twelve years practical experience estimating, designing, taking care sub-contractors, and following up jobs to completion on all types of structures. Intimate knowledge of all phases of construction. Excellent references. B-1168.

Estimator; Jun. Am. Soc. C.E.; civil engineering graduate, Rensselaer Polytechnic Institute, 1929. Desires position with marble, tile, and terazzo contractor. Has had practically complete charge of well known concern. Estimates, requisitions, material orders, detail drawings, and job supervision. Also varied experience with other contractors. Salary open to offer. C-7157.

Civil and Construction Engineer; M. Am. Soc. C.E.; age 40; married. Twenty-

five years experience in design, construction, valuation, estimating, foundation problems, reports, reconnaissance, and locating. Have been employed by railroads, contractors, state, schools, industrial firms, and owners. Interested in similar connections. B-4802.

CIVIL ENGINEER; 25; single; American. Three years university work in engineering. Four years experience laying double tracks, puzzle switches, cross-overs, running levels, and transit work with railroads. Tropical experience in topography, railroad bridge construction, and drafting and plotting contour maps. Available at once. Will go anywhere. References. C-7443.

TECHNICAL GRADUATE; Assoc. M. Am. Soc. C.E.; industrial plant, process planning. Material handling, both bulk and commodity. New construction, maintenance, production as plant engineer, and operating foreman. Supervise layout, construction, and operation of municipal plants. Can handle design and erection of structural steel, reinforced concrete; construction cost accounting, estimating, and sub-contracts. C-6840.

YOUNG MAN; to graduate as civil engineer from Rensselaer Polytechnic Institute, June 1931; Brazilian; 22; desires position in the construction or sales field, either in this country or South America. Speaks English, French, German, Portuguese, and Spanish. C-8835.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; estimates; valuation; C.E., Rensselaer Polytechnic Institute, 1902; 11 years field work; 15 years office work; tunnel, concrete, building construction, concrete and steel design, building estimates, investigations and reports of bridges, railroads, harbor construction, valuation of bridges, concrete structures, buildings, tunnels, water works; 4 years foreign. Available immediately. B-5455.

CIVIL ENGINEER; M. Am. Soc. C.E.; graduate engineer, University of Michigan; age 36; married; Protestant. Two years resident engineer water works construction; 10 years in public utility work, as superintendent and general manager of water and light departments. Desires executive position in public utility or industrial field. B-4866.

MANAGER; Assoc. M. Am. Soc. C.E.; with building contractor; age 40; technical graduate. Experienced in building construction in executive and practical capacity. Ability to handle negotiations with architects and owners. Available immediately. Location, East or Middle West. C-8528.

CONSTRUCTION AND DESIGNING ENGINEER; Assoc. M. Am. Soc. C.E.; graduate; 46; married; 24 years varied practice; working knowledge of Spanish and German; experience in Latin America, Orient, Eastern United States; surveys, topographic and hydrologic; investigations, reports, design, construction; railroad, municipal, water supply, water power, dams, port works, bridges, pnuematic caissons, floating plant; available short notice. B-657.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; married; Cornell graduate; desires to become connected with construction firm; 3 years experience on concrete and asphalt pavement survey; design, estimate, and construction of stone-faced reinforced concrete arch bridges. C-6511.

ENGINEERING EXECUTIVE; M. Am. Soc. C.E.; 25 years experience on municipal, highway, and allied lines. Responsible position desired. Middle States preferred. Available on short notice. C-8700.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; university graduate, 1928; age 27; 3 months drafting; 3 months assistant estimator and designer; will do any kind of work; available at once. Location in United States preferred. C-4609.

DIRECTOR OF ENGINEERING AND PROFESSOR OF CIVIL ENGINEERING; M. Am. Soc. C.E.; desires position as head of department of civil or highway engineering or as dean in a recognized institution. Exceptional record of 16 years practical experience. Graduate of Massachusetts Institute of Technology. Prefers East or Middle West. Trained executive. B-6574.

CIVIL ENGINEER; M. Am. Soc. C.E.; Cornell graduate, Master's degree; 18 years broad, responsible practice and teaching experience. Practice covers design, construction, experimentation, and promotion work; special work in sanitary engineering; varied teaching in civil engineering. Desires work as department head in college or other responsible position. Available July 1 or September 15. B-7678.

ENGINEER; Assoc. M. Am. Soc. C.E.; 32; American; 12 years experience in public utility investigation, design, and construction, power plants valuations, economics, interconnections, reports, building construction, hydraulics, and structural design. Available immediately. Location immaterial. C-6970.

ARCHITECT AND ENGINEER; M. Am. Soc. C.E.; 30 years experience, covering design of building, steel and concrete structures, and equipment as squad leader, chief draftsman, specification writer, estimator, and superintendent; also some experience as plant engineer. Prefers Boston or New York. C-4918.

EXECUTIVE ENGINEER; M. Am. Soc. C.E.; well qualified as assistant to president or vice-president of large business; 20 years experience in engineering and constructing with work leading to positions of chief engineer and construction engineer. Sound training in economics, analysis of business, reports for financing, reorganizations, and income tax purposes. University lecturer in economics. Public speaking instructor. University graduate. B-2688.

Positions Available

CONSTRUCTION SUPERINTENDENT; must have had experience with contractor and have been responsible for costs on industrial construction contracts in the vicinity of large cities; must have good personality for business relations, be a good leader of men, and have had 10 years experience in handling construction labor, including skilled mechanics; must know concrete, jackforms, and unusual structures, including docks and piling, also conveying and mechanical equipment, such as skiphoists, trolleys, bucket, belt, chain, and other types of elevators, conveyors, mast, gaff-rigs, and other water-side material handling equipment. Apply only by letter. Location in Atlantic States but some traveling required. W-2473.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on pages 87 to 89 of the Year Book for 1931. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

BALKENBRÜCKEN. By W. Gehler. (Handbuch für Eisenbetonbau, edited by F. Emperger, bd. 6, lief. 1–6). 3 ed. Berlin, Wilhelm Ernst & Sohn, 1929–1931. 6 pts., 535 pp., illus., diagrs., 10 × 7 in., paper. Pt. 1–5, 6.80 r.m. each. Pt. 6, 65.50 r.m.

An elaborate treatise on the design and construction of truss bridges of reinforced concrete. The general principles of these bridges, the basic types, and the application of these types to highway and railroad work are described in detail. The use of reinforced concrete in metal bridges, and the testing and maintenance of bridges are also discussed. Many actual bridges are described, and the work is elaborately illustrated with photographs and drawings.

BELASTUNGSGLIEDER. By A. Kleinlogel. 4 ed. Berlin, Wilhelm Ernst & Sohn, 1931. 117 pp., illus., diagrs., tables, 10 × 7 in., paper. 7.80 r.m.

A convenient reference book for the designer of structures, which contains formulas and tables for determining the moments and shears in simple beams under all varieties of loading.

BUILDINGS—THEIR USES AND THE SPACES ABOUT THEM. Published by the Regional Plan of New York and Its Environs, New York. 465 pp., illus., tables, 8½ × 11 in. $3.00.

The final volume of the Regional Survey Series, devoted to a consideration of buildings in their relation to the city and regional plan. A consideration of the differences between residence, business, and industrial buildings and of one of the principal methods of building control—zoning.

BULLETIN OF THE NATIONAL RESEARCH COUNCIL. 4 ed. By the National Research Council of the National Academy of Sciences, Washington, D.C. 267 pp. $3.00.

More than 1,600 laboratories are listed in this edition, as compared with 1,000 in the third edition.

ECONOMIC CONTROL OF ENGINEERING AND MANUFACTURING. By Frank L. Eidmann. New York, McGraw-Hill Book Co., 1931. 402 pp., illus., diagrs., tables, 9 × 6 in., cloth. $4.00.

This book points out problems of engineering and manufacturing, which must be solved by economic analysis, and presents methods of procedure for their solution. Among the matters discussed are the choice between different types of equipment, the determination of the economy of proposed changes in equipment, processes, or methods, the proper amount of materials to keep in stock, the economic effects of artificial illumination, and similar problems.

ELEMENTS OF WATER BACTERIOLOGY WITH SPECIAL REFERENCE TO SANITARY WATER ANALYSIS. By S. C. Prescott and C. E. A. Winslow. 5 ed. New York, John Wiley and Sons, 1931. 219 pp., tables. $2.50.

Edition follows that of 1924 in general, but new procedures of value have been introduced and extensive bibliography has been brought up to date. This book has long been valued as a guide to best American practices, and is arranged to meet the needs of sanitary engineers, public hygienists, and others interested in water and sewage problems.

HIGHWAY ECONOMICS. By S. Johannesson. New York, McGraw-Hill Book Co., 1931. 157 pp., illus., tables. $2.50.

Introduction to economics of highway construction, which aims to present principles and methods by which cost of producing a finished highway may be determined, and also the cost of operating it. Among topics treated are cost of vehicle operation upon highways, cost of delays, loss of time by interruptions of traffic, highway capacity, grade crossing elimination, economic studies, and traffic surveys.

JAHRBUCH DER HAFENBAUTECHNISCHEN GESELLSCHAFT, v. 11, 1928–1929. Hamburg, The Society, 1930. For sale by V. D. I. Verlag, Berlin. 367 pp., illus., plates, port., maps, tables, 12 × 9 in., cloth. 45 r.m.

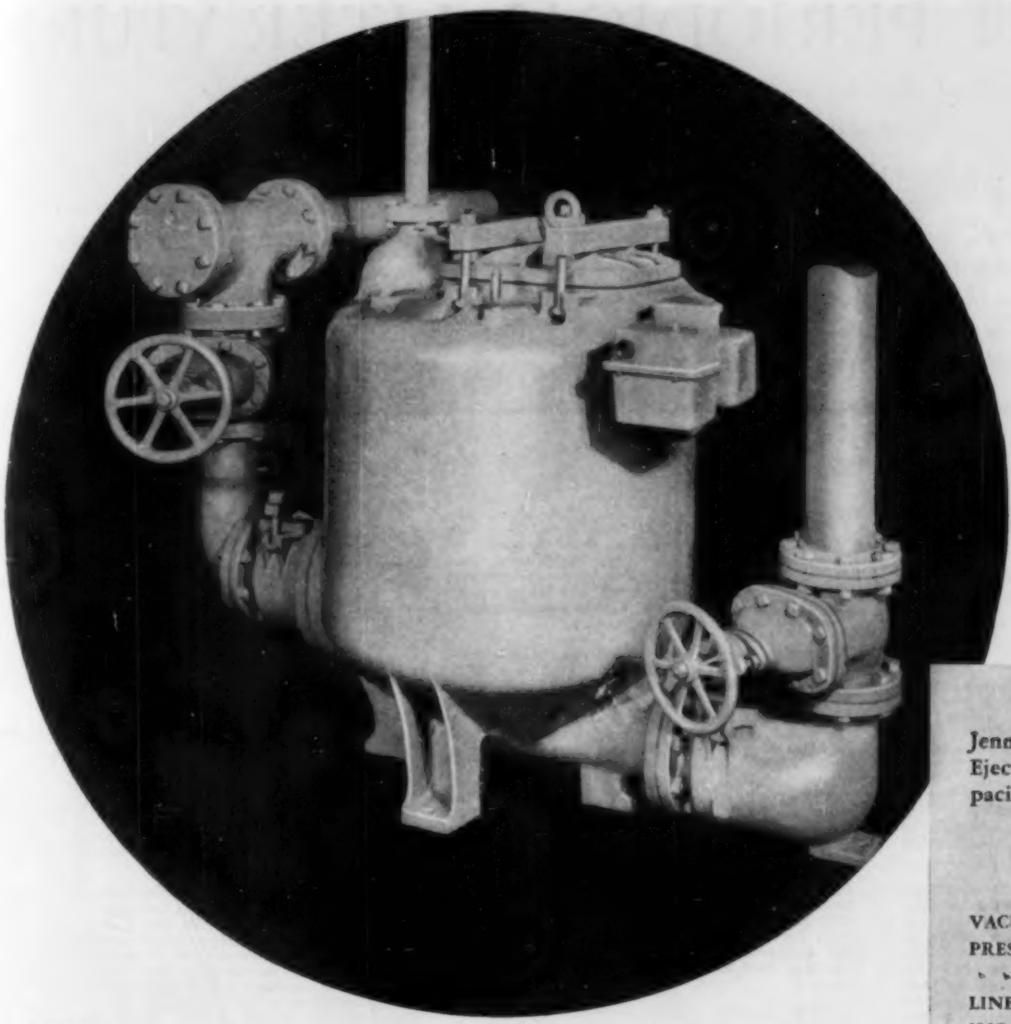
Contains, in addition to the official proceedings of the Society, the lectures and reports presented at the two annual meetings. These papers describe the more important developments in harbor construction, terminal warehouses, canals, and internal waterways in Germany during recent years.

STEEL CONSTRUCTION. By Henry Jackson Burt. Revised by Herman Ritow. Chicago, American Technical Society, 1931. 420 pp., illus., diagrs., tables, 9 × 6 in., cloth. $2.50.

As indicated by the title, this book discusses the practical steps in designing steel framework. The usual methods of calculating the loads on the members and the resistance of members are given, and their use is illustrated by many examples. Methods for detailing connections are also given. Complete calculations for a sixteen-story hotel are included.

TABLES OF CHEMICAL COMPOSITIONS, PHYSICAL AND MECHANICAL PROPERTIES AND CORROSION-RESISTANT PROPERTIES OF CORROSION-RESISTANT AND HEAT-RESISTANT ALLOYS. Reprinted from the copyrighted *Proceedings*, vol. 30, Part 1, 1930, of *The American Society for Testing Materials*.

Report of Committee A-10 and B-3 on corrosion of non-ferrous metals and alloys, iron-chromium, iron nickel, and related alloys. General committee activities; subcommittee activities on classification of data, nomenclature, methods of chemical analysis, and corrosion testing.



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BRIDGES

ARCHES, DESIGN. A Method of Arch Design, G. P. Manning. *Concrete and Constr. Eng.*, vol. 26, no. 2, Feb. 1931, pp. 130–140, 9 figs. Approximate crown sections; temperature and crown-drop stresses; stresses due to uniform dead load; stress due to spandrel load; stresses due to live load. (Continuation of serial.)

COMBINED, EGYPT. A New Nile Bridge in Uganda. *Engineer*, vol. 151, no. 3914, Jan. 16, 1931, p. 74, 2 figs. Road and rail bridge consists of spandrel-braced arch, 260-ft. long, with approach span 100-ft. long; 20-ft. roadway is suspended below arch, and there are two footways. Bridge was completely erected on its own gearings in yard of P. and W. MacLellan Ltd., at Glasgow, and was afterward dismantled and shipped to Uganda in sections.

CONSTRUCTION. The Development of Bridge Construction, P. G. Laurson. *Jl. Eng. Education*, vol. 21, no. 6, Feb. 1931, pp. 433–453, 16 figs. History of bridge design and construction through 30 centuries.

MASONRY ARCH. Progrès depuis cinquante ans dans l'art de projeter et d'exécuter de grandes voutes en maconnerie (50 Years' Progress in the Art of Designing and Construction of Great Masonry Arches), P. Sejourne. *Génie Civil*, 50th Anniversary Number, 1930, pp. 193–198, 16 figs. Statistical data and review of methods of design and construction of long-span ashlar and concrete-arch bridges in Europe, America, and other parts of world.

PONTOON. The Status of Pontoon Bridge Development, F. H. Kohloss. *Military Engr.*, vol. 23, no. 127, Jan.–Feb. 1931, pp. 46–49, 6 figs. History of pontoon-bridge construction with details of heavy, medium, and light types.

RAILROAD, MALAYA. Railway Bridge Construction in Malaya, J. E. Holmstrom. *Structural Engr.*, vol. 9, no. 2, Feb. 1931, pp. 70–82, 13 figs. Construction of permanent bridges; method of forming concrete well curb; device for undercutting well curb in hard ground. (To be concluded.)

STEEL, MOVING. Raising a Two-Span Highway Bridge, H. L. Parr. *Eng. and Contracting*, vol. 70, no. 2, Feb. 1931, pp. 41–43, 2 figs. Moving and raising old pin-connected bridge of two 139-ft. spans, for vertical distance of 21 ft. Temporary piles were driven and capped on downstream side of each existing supporting caisson. Each span was realigned by jacking one end at a time sideways, until supporting shoes were off old caissons and supported on piling, while old caissons were wrecked and new concrete foundations built.

STEEL TRUSS, CANADA. Bridge with Unusual Features of Design and Construction, P. Savage. *Contract Rec.*, vol. 45, no. 4, Jan. 28, 1931, pp. 78–80, 4 figs. Description of steel truss bridge over Rapide Blanc on St. Maurice River. Depth and swiftness of river made use of falsework virtually impossible, as result of which it was deemed advisable to erect by cantilevering from west bank. Structure consists of Pratt truss, modified to permit of cantilever erection, and pony truss. Anchor arm span is 78 ft., main span 260 ft., and pony truss 78 ft. Paper read before Eng. Inst. of Canada.

SUSPENSION, HUDSON RIVER. Construction of the $12,400,000 Cables for 3,500-ft. Main Span, Hudson River Bridge, F. W. Skinner. *West. Construction News*, vol. 6, no. 3, Feb. 10, 1931, pp. 58–62, 12 figs. Discussion of improved methods, special equipment, and unprecedented speed; cable investigations; placing cable wire; adjusting and compacting strands; cable plant; progress.

BUILDINGS

DESIGN. Behind the Scenes in Building Planning, R. M. Hood. *Eng. News-Rec.*, vol. 106, no. 8, Feb. 19, 1931, pp. 314–316, 8 figs. Modern building planning and design; co-operation among architects, engineers, and contractors on large building projects explained by describing development of Daily News Building, in New York City; advantages of cost-plus; planning in conference.

STEEL ELECTRIC WELDING. Three Arc-Welded Buildings, F. P. McKibben. *General Bldg. Contractor*, vol. 2, no. 1, Jan. 1931, pp. 19–21, 3 figs. Office building of Dallas Power and Light Company, Dallas, Tex., shop and field arc-welded; illuminating company's office building, Tremont Street, Boston, Mass., 14 stories, shop riveted and field arc-welded; Dupont office building, Wilmington, Del., 14 stories, shop riveted and field arc-welded; noise elimination.

WATER SUPPLY. Application of Engineering Data in the Design of Water Supply Systems. *Plumbers Trade Jl.*, vol. 90, no. 3, Feb. 1, 1931, pp. 22–23 and 66–67, 1 fig. Quantity of water required; appropriate working pressures; available pressure drops for figuring practical pipe sizes for different classes of work. Outline of hot and cold water supply system for 10-story building used as basis for study of practical pipe sizes.

WIND BRACING. Basis of Design for Hurricane Exposure. A. Smith, *Am. Concrete Inst.—Jl.*, vol. 2, no. 7, Mar. 1931, pp. 903–924, 5 figs. Report of Committee 308; design units; wind-pressure units; example of wind-stress computation; development of formula; diagram of framing for determining stiffness factors for wind stresses; calculation of eccentricity and of corrections; accuracy of method; final solution for very unsymmetrical buildings; accuracy of conventional methods.

Measuring the Behavior of Tall Buildings, D. C. Coyle. *Eng. News-Rec.*, vol. 106, no. 8, Feb. 19, 1931, pp. 310–313, 7 figs. Review of recently developed horizontal-pendulum instrument stiffness of building, as expressed by amplitude of vibrations caused by wind gusts, may be quantitatively recorded. Details of vibration-measuring instrument; variation of calibration "constant" with frequency; interpreting instrument readings; vibration curves for same building in different winds; allowable deflection.

Wind Design for 1,000-Ft. Tower Buildings. *Eng. News-Rec.*, vol. 106, no. 8, Feb. 19, 1931, pp. 331–334, 5 figs. Discussion of common methods of analysis that emphasizes sway resistance in addition to strength, as exemplified most recently in designs of Empire State and Manhattan Company buildings in New York. Column and wind bracing details of the Empire State Building. Maximum columns in recent tall New York buildings.

CONCRETE

AGGREGATES. Separated Sizes of Coarse Aggregate in the Proportioning of Concrete, R. W. Crum. *Pit and Quarry*, vol. 21, no. 10, Feb. 11, 1931, pp. 72–76, 4 figs. Use of coarse aggregate separated into two or more sizes in construction of concrete pavements found feasible. Theory of concrete mixtures; cost of materials; effect of batch size; workability; durability; strength and uniformity; and analysis of costs are before National Sand and Gravel Association.

CREEP. Flow of Concrete Under the Action of Sustained Loads, R. E. Davis and H. E. Davis. *Am. Concrete Inst.—Jl.*, vol. 2, no. 7, Mar. 1931, pp. 837–901, 26 figs. Results of tests on plain and reinforced concrete to determine effect of loads sustained over considerable period of time upon deformations and upon distribution of stresses in concrete and steel. Effect upon flow of richness of mix, gradation of aggregate, and water-cement ratio; effect of condition of storage; effect of age at time of loading upon flow and of reinforcement upon flow and stress.

DESIGN CHARTS. Short-Cuts in Structural Design, J. R. Griffith. *Concrete*, vol. 38, no. 2, Feb. 1931, pp. 45–48, 2 figs. Charts for finding required steel area and actual stress in concrete in beams and slabs; unbalanced reinforcing; values for modulus ratio; examples illustrating use of charts. (To be continued.)

MIXERS, TESTING. A Comparison of Continuous with Batch Mixers in Plant Operation, B. Wilk. *Am. Concrete Inst.—Jl.*, vol. 2, no. 6, Feb. 1931, pp. 655–659. Report on tests indicating that variation between strength of block made from continuous mixer of long trough type and usual batch mixer is very small, although time of mixing in continuous mixer is approximately one minute as against six minutes in batch mixer.

MIXING. Chicago and Northwestern Establishes Quality Control of Concrete, O. F. Dalstrom. *Concrete*, vol. 38, no. 2, Feb. 1931, pp. 19–22, 3 figs. Bridge department establishes water cement ratio method of controlling quality of concrete; introducing new way of making concrete; itemized list of field testing equipment required, with approximate cost; automatic control of mixing time; distribution of test reports; how test specimens are handled; checking up on quality of aggregates.

MIXING, COLD WEATHER. Only Water and Sand Need Heating in Cold Weather Concreting, I. E. Burks and G. D. Durham. *Concrete*, vol. 38, no. 2, Feb. 1931, pp. 35–38, 5 figs. Discussion previously indexed from *Am. Concrete Inst.—Jl.*, issue of Nov. 1930.

SLABS, CONSTRUCTION. A Steel-Form System for Flat-Slab Construction, H. W. Roos. *General Bldg. Contractor*, vol. 2, no. 1, Jan. 1931, pp. 24–28, 15 figs. Description of new method of form erection for flat-slab construction, consisting of steel forms interlocking with specially designed shore head. Mechanical friction grip obviates necessity of nailing units together.

TESTING. Some Long-Time Tests of Concrete, M. O. Withey. *Am. Concrete Inst.—Jl.*, vol. 2, no. 6, Feb. 1931, pp. 547–582, 14 figs. Report on University of Wisconsin experiments to ascertain age-strength relationship for concrete cured under common conditions. Program included compression, absorption, and alternate freezing and thawing tests; specimens to be tested at 10 intervals over century; effect of storage on tensile strength of cement; strength-age curves; effect of mix and type of aggregate on absorption of concrete and on strength of concrete when subjected to freezing and thawing; expansion and contraction and loss of water in curing; relationship between strength and water-cement ratio.

DAMS

CONCRETE, CONSTRUCTION. Design and Control of Concrete for Diablo Dam, H. F. Faulkner and R. R. Hubbard. *Am. Concrete Inst.—Jl.*, vol. 2, no. 6, Feb. 1931, pp. 529–545, 6 figs. Report on construction of curved concrete dam of constant angle arch type, terminating at each end in gravity abutment sections, in which are spillways; dam is 390 ft. high, with crest length of 1,170 ft., and contains 320,000 cu. yd. of concrete.

CONCRETE, EGYPT. The Nag Hammadi Barrage. *Engineer*, vol. 151, nos. 3916 and 3917, Jan. 30, 1931, pp. 122–124, and Feb. 6,

pp. 150–152, 19 figs. partly on pp. 134 and 160. Dam is one of number of schemes devised to provide better irrigation for Upper Egypt, and increase the supply of water for Egypt generally. Situated nearly half-way between Esna, or Isna, and Assiut Barrages, 367 miles from Cairo, the total length of the dam between centers of abutment piers is 822.25 m. There are 100 sluice openings, each having width of 6 m.; and most of piers will be 8.5 m.

CUT-OFF WALLS. Cut-off Walls for Dams, C. C. Tillotson. *West. Construction News*, vol. 6, no. 3, Feb. 10, 1931, pp. 67–68, 3 figs. Classification of cut-off walls for dams of various types and materials, uplift pressure, and factor of safety.

DESIGN. Comments on a Few Dams and Reservoirs, C. E. Grunsky. *Military Engr.*, vol. 23, no. 127, Jan.–Feb. 1931, pp. 50–56, 9 figs. Brief comments on Elephant Butte Dam, New Mexico; Laguna Dam, Arizona-California: Victor Dam, Colorado; Big Meadows Dam, Lake Almanor, California; Copco Dam, California-Oregon; Lost River Dam, Idaho; Purisima Dam, California; Lake Hodges Dam, California; Merced Falls Dam, California; Calaveras Dam, California. (Continuation of serial.)

DESIGN. Some New Ideas on Dams, E. Godfrey. *Engineer*, vol. 151, no. 3917, Feb. 6, 1931, pp. 157–158. Paper before Instn. Structural Engineers, previously indexed from *Structural Engr.*, Jan. 1931.

EARTH, SANTIAGO CREEK, CALIF. Santiago Creek Earth-Fill Dam Near Orange, California. *West. Construction News*, vol. 6, no. 3, Feb. 10, 1931, pp. 63–64, 3 figs. Features of irrigation reservoir dam, 125 ft. high, projected for Serrano and Carpenter irrigation districts and estimated to cost about $725,000.

GRAVITY STRESSES. Stresses in Gravity Dams by Principle of Least Work, B. F. Jakobsen. *Am. Soc. Civil Engrs.—Proc.*, vol. 57, no. 2, Feb. 1931, pp. 351–357, 3 figs. Discussion by F. W. Ely and M. H. Gerry, Jr., of paper indexed in Engineering Index 1930, from issue of Sept. 1930.

HOOVER DAM, SPECIFICATIONS. Hoover Dam Specifications. *West. Construction News*, vol. 6, no. 1, Jan. 10, 1931, pp. 2–11, 6 figs., 4 special plates. Unusual features include cofferdams built to government specifications and contractor relieved of liability after completion of same; concrete to be placed in columnar units and pressure-grouted, using refrigeration system to control internal heat; bids under single contract for dam, appurtenant structures and power house; quantities of excavation, backfill, rockfill, earth fill, steelwork, and concrete work.

Specifications, Schedule, and Drawings for Hoover Dam, Power Plant, and Appurtenant Works. *U.S. Bur. Reclamation—Specifications*, no. 519, 94 pp., 78 figs. on supp. plates. Specifications cover following items: earthwork; grout and drainage systems; roofs; concrete; metal work and painting; pipes and structural steel; gates and other mechanical machinery; electrical installations; windows, doors, and other miscellaneous items.

RESERVOIRS, CONCRETE, GREAT BRITAIN. Barming Service Reservoir Extension. *Water and Water Eng.*, vol. 33, no. 385, Jan. 20, 1931, pp. 5–9, 6 figs. Design and construction of covered service reservoir of three-quarters of million gallon capacity. Retaining wall is 180 yd. in length and varies from 6 ft. 9 in. to 13 ft. 3 in. in height. Steel is erected as rigid self-supporting skeleton to which mould for reinforcing concrete is attached.

RESERVOIRS, GEOLOGY. A Geologic Study of the Madden Dam Project, Alhajuela, Canal Zone, F. Reeves and C. P. Ross. *U.S. Dept. Interior.—Geol. Survey Bul.*, no. 821-B, 1930, pp. 11–49, 5 figs., 6 supp. plates, 3 maps. Report on geologic survey of reservoir site on upper Rio Chagres, near Alhajuela, Canal Zone, for storage of flood water for use in Panama Canal for lockage, possible development of hydro-electric power, and to aid in avoiding disturbing currents in canal. Geologists recommend that maximum water level be made 20 ft. lower than originally contemplated. Leakage will find its way into Gatun Lake, where it is desired.

RESERVOIRS, LINING. Sealing Chenery Reservoir, C. H. Lee. *West. Construction News*, vol. 5, no. 24, Dec. 25, 1930, pp. 621–625, 10 figs. Reduction of seepage losses from water-supply reservoir by method which consists of impregnating and covering leaky portions of reservoir bottom with layer of colloidal material (Betonite), which settles out from suspension discharged under water just above bottom; reduction in leakage, of about 60 per cent, accomplished at fraction of cost; of lining by conventional methods; selection of sealing material; mixing and placing; difficulties and results.

WEIRS, GATES. Hinged Steel Weir Gates in the Vale Project Diversion Dam. *Eng. News-Rec.*, vol. 105, no. 26, Dec. 25, 1930, pp. 1009–1010, 4 figs. Gate panels lowered into structures below spillway lip to leave clear space between piers for passage of large ice cakes; steel weir assembly and hinge details.

FLOOD CONTROL

MISSISSIPPI RIVER. Progress in Mississippi River Flood Control. *Eng. News-Rec.*, vol. 106, no. 6, Feb. 5, 1931, pp. 250–252, 2 figs. Summary, by staff engineers of Mississippi River Commission, of expenditures made and construction accomplished in two and one-half years; funds obligated and expended; contraction work experiments; bank protection problems; remarkable levee records made; and incidental operations.

REVETMENT. Articulated-Concrete Revetment Construction on the Mississippi River, M. W. Gilland. *Eng. News-Rec.*, vol. 105, no. 26, Dec. 25, 1930, pp. 996–1003, 18 figs. Method of casting mat sections of 25 articulated blocks, assembling these sections into articulated mats 140 ft. wide and 250 to 300 ft. long, and sinking mats on underwater bank of river; plant arrangement for sinking articulated-mat concrete revetment; plan of Greenville plant for casting mat sections; mixing barges for casting plant.

FLOW OF FLUIDS

CURVED CHANNELS. Flow of Water Around Bends. *Eng. News-Rec.*, vol. 106, no. 4, Jan. 22, 1931, p. 161. Discussion by D. B. Freeman of paper indexed in Engineering Index 1930, from issue of Sept. 4, 1930.

MEASUREMENT. Measuring Irrigation Deliveries in the Panjab, E. S. Lindley. *Am. Soc. Civil Engrs.—Proc.*, vol. 57, no. 2, Feb. 1931, pp. 269–283, 3 figs. Conditions of Indian canals as affecting problem of distributing supplies in manner desired; devices available for effecting such distribution with minimum of manual control; records of investigations directed to their improvement; theories on which to base design and using of such devices to form complete scheme of automatic distribution; practice of group distribution.

Measuring Large Flows. *Eng. News-Rec.*, vol. 106, no. 5, Jan. 29, 1931, pp. 183–188, 12 figs. Symposium of three articles upon application of Venturi principle to specific problems: Flow in Silt-Laden Canal Gaged by Contracted Flume, R. L. Parshall; Determining Coefficients for Large Venturi Meters, S. F. Coghlan; A Practical Venturi Meter for Irrigation Service, J. E. Christiansen and I. H. Teilman. Discharge coefficient curves for usual and modified formula; arrangement and dimensions of irrigation Venturi meter; precast Venturi tubes; results of tests on half-size model of irrigation Venturi meter.

OPEN CHANNELS. A Discharge Diagram for Uniform Flow in Open Channels, M. Blanchard. *Am. Soc. Civil Engrs.—Proc.*, vol. 57, no. 1, Jan. 1931, pp. 113–118, 7 figs. Diagram of discharge stage and slope relation, based on Chezy formula and designed to give discharge at any stage for falls that create resulting discharges; practical application to discharge measurements on Chicago Sanitary District Canal with regulated flows in uniform rock section.

ORIFICES. The Flow of Fluids Through Orifices in Six-Inch Pipes, S. R. Beitler and P. Bucher. *Hydraulics (A.S.M.E. Trans.)*, vol. 52, no. 30, Sept.–Dec. 1930, pp. 77–87, 21 figs. Indexed in Engineering Index 1929, p. 1,341, from Advance Paper no. 2, for mtg. Dec. 2–6, 1929.

WIND TUNNELS, GREAT BRITAIN. The Design of Wind Tunnels, E. F. Relf. *Aircraft Eng.*, vol. 3, no. 24, Feb. 1931, pp. 27–28 and 34, 8 figs. Review of past history and present tendencies with particular regard to advantages of open-jet return flow type of National Physical laboratories; comparison of various wind tunnels and data on power economy.

FOUNDATIONS

BRIDGE PIERS. An Overturned 19,000-Ton Caisson Successfully Salvaged, G. B. Woodruff. *Eng. News-Rec.*, vol. 106, no. 7, Feb. 12, 1931, pp. 275–281, 7 figs. A 19,000-ton mass of concrete for base of one of Mid-Hudson Bridge piers, Poughkeepsie, N.Y., careened in mud, 60 ft. below water, when its sinking had just begun; 15 months required to set it upright again. In order to right caisson, weighted booms and pulling tackles anchored to sunken cribs were rigged to apply 1,500 tons pull at top edge, while soil was being dug away. A review of design and construction is included.

COFFERDAMS. Steel Sheeting Piling in Cofferdam, J. C. Meem. *Brooklyn Engrs.' Club—Proc.*, vol. 29, part 1, Oct. 1930, pp. 27–51, 15 plates. Classification and methods of construction of sheet-piling cofferdams, with special reference to Black Rock Cofferdam used in construction of United States ship lock in Black Rock Harbor, Buffalo, N.Y. Paper read at Int. Congress on Steel Structures at Liége, Belgium, Sept. 1930.

DAMS, GRAVITY ARCH. Foundation Procedure at Owyhee Dam. *Eng. News-Rec.*, vol. 106, no. 5, Jan. 29, 1931, pp. 178–182, 7 figs. Mining methods used to remove 38,000 cu. vd. of faulted material to sound rock 190 ft. below stream bed. Concrete deposited at 1,000 cu. yd. per shift by 8-cu. yd. buckets from overhead cableway. Detailed descriptions of the following are given: concrete plant; concrete placing; characteristics of typical 4-yd. batch; grout outlet for contraction joints; ultimate height of dam 530 ft.

HIGH BUILDINGS. Difficult Structural Problems in Erecting Sun Life Building, Montreal—2, A. H. Harkness. *Contract Rec.*, vol. 45, no. 7, Feb. 18, 1931, pp. 149–153, 7 figs. Details of column reinforcement and problems involved, such as, sloping and hanging columns. Before Eng. Inst. Canada.

Foundations for New York Office Building Beyond Old Hudson River Shore Line, W. T. McIntosh. *Eng. and Contracting*, vol. 70, no. 2, Feb. 1931, pp. 32–34, 3 figs. Forty-two open caissons through old cribwork and river silt installed in midwinter in 27 working days, for new office building at 21 West St., New York City, approximately 75 ft. by 100 ft. in ground area and 33 stories high.

MODERN. Modern Methods of Construction and Design of Foundations, M. A. Korni and J. Chambers. *Indian Eng. (Calcutta)*, vol. 88, no. 23, Dec. 6, 1930, pp. 496–498, 7 figs. Electrical method for sub-soil studies in connection with foundation work; causes of foundation failures; description of various kinds of foundation soil; minor improvements of foundation soil of low-bearing capacity.

MATERIALS TESTING

COLUMNS. Composite Columns, L. J. Mensch. *Am. Concrete Inst.—Jl.*, vol. 2, no. 3, Nov. 1930, pp. 263–280, 8 figs. Results of tests and principles of design of concrete columns hooped with spiral- and vertical-reinforcement sand with additional heavy strengthening member or members of cast iron or steel inside-hooping; tests of composite columns made at University of Illinois; typical footing for composite column; comparative design of Emperger columns and standard hooped concrete columns for tall building according to Chicago code; composite column forming part of wind-bracing system.

CONCRETE, SPECIFICATIONS. Tentative Laboratory Method of Making Flexure Tests of Concrete, Using a Simple Beam with Center Loading. *Am. Soc. Testing Matls.—Tentative Standards*, 1930, pp. 181–186, 2 figs. Methods are intended to cover making of flexure tests of concrete in laboratory where accurate control of quantities of materials and test conditions is possible; they are intended to apply to hand-mixed concrete with slight modification from that used in making compression test specimens.

METALS FATIGUE. Fatigue of Metals, J. A. G. Stuart. *Mech. World*, vol. 89, no. 2,302, Feb 13, 1931, pp. 155–158, 7 figs. Consideration of tensile and compressive stresses and reverse bending stresses; chief results of Wohler's experiments; Haigh test; representation of results graphically.

METHODS. On What Test Value Should Working Stress Be Based? H. F. Moore. *Machine Design*, vol. 3, no. 2, Feb. 1931, pp. 35–38, 4 figs. Principal testing methods with particular regard to tensile strength, fatigue test, corrosion fatigue limits, impact testing, and safety factors.

STRAIN GAGES. Stress Analysis by Strain Gages, T. W. Greene. *Product Eng.*, vol. 2, no. 1, Jan. 1931, pp. 11–13, 5 figs. How to use these instruments and how to interpret resulting data for analyzing stress distribution in old and new designs.

STRESS ANALYSIS. Some Experimental Methods and Apparatus for Determining the Stresses in Bridges and Framed Structures, E. G. Coker. *Instn. Civil Engrs.—Proc. (Lond.)*, vol. 229, pt. 1, 1929–30, pp. 33–53, 9 figs. Paper indexed in Engineering Index 1929, p. 814, from *Engineering*, Nov. 29, 1929.

STRESSES. Stresses Due to Pressure of One Elastic Solid Upon Another with Special Reference to Rails. *Railroad Herald*, vol. 35, no. 1, Dec. 1930, pp. 27–30, 1 fig. Discussion of four theories advanced; methods of checking mathematical analysis. Article from Bulletin of Engineering Experiment Station of Univ. of Ill.

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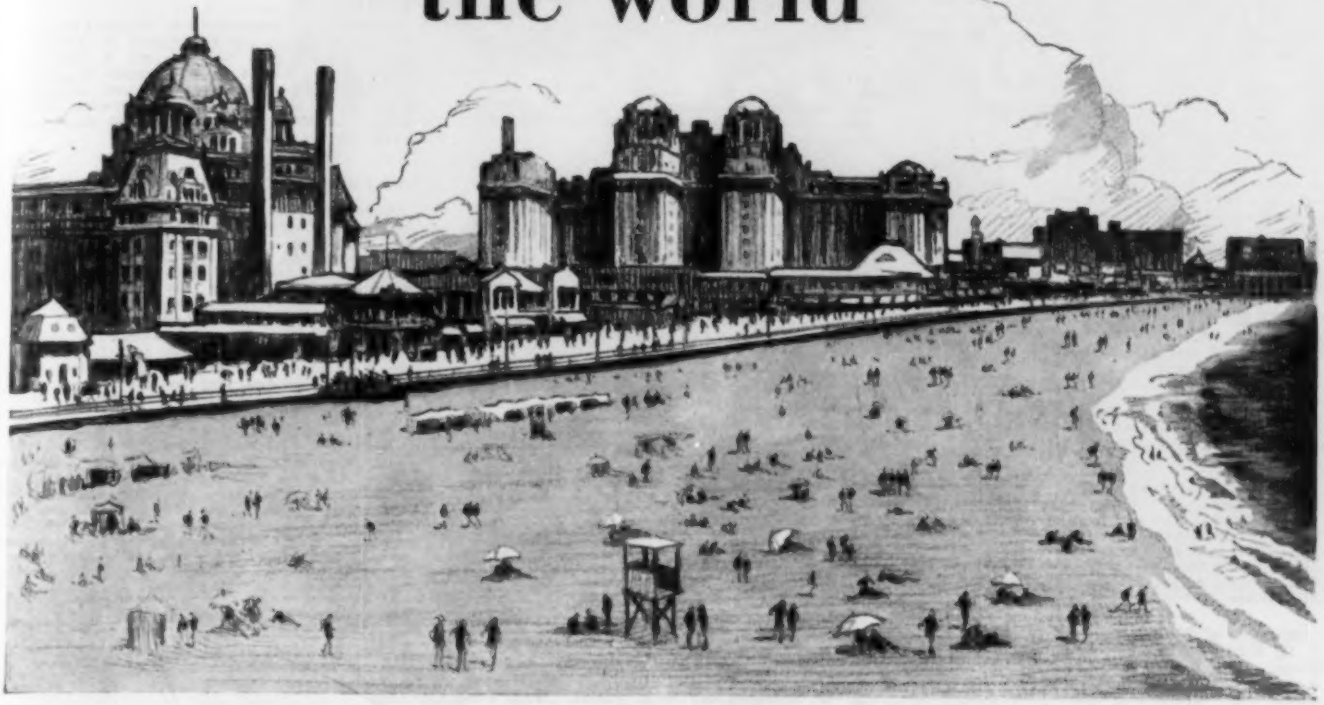

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SUBWAYS, COLUMN BASES. Compressive Tests on Bases for Subway Columns, J. H. Edwards, H. L. Whittemore, and A. H. Strang. *U.S. Bur. Standards—Jl. Research*, vol. 5, no. 3, Sept. 1930, pp. 619–626, 8 figs. Tests were made of three welded bases and six riveted bases, three without base plates and three with base plates, to determine whether welded design was satisfactory; specimens were loaded with base on span of 12 in.; some hand strain-gage readings were taken to study press distribution; strength of welded specimens and riveted specimens having base plates was practically same; H-section deformed greatly at maximum load, and stiffeners in base buckled.

TESTING MACHINES. A 3,000,000-lb. Testing Machine. W. M. Wilson. *Eng. and Contracting*, vol. 69, no. 8, Aug. 1930, pp. 292–293, 3 figs. Machine in new laboratory at University of Illinois has capacity in either tension or compression of 3,000,000 lb.; clear distance between screws is 7 ft. 6 in., and maximum clear height from bottom of compression head to top of bed of machine is 38 ft. 6 in.

WALLS, MASONRY. Methods Used in Testing Masonry Specimens for Bending, Tension, and Shear, N. W. Kelch. *Am. Ceramic Soc.—Jl.*, vol. 14, no. 2, Feb. 1931, pp. 125–132, 9 figs. Twenty-four walls, $4^1/_2$ ft. wide, $5^1/_2$ ft. high, some 8 in. and some 12 in. thick, were tested for bending after aging 60 days and 6 months, respectively. It was shown that aging of lime mortar is essential and that failures in shearing stress were also due to immature mortar, while brick masonry withstands earthquake shocks when mortar is matured by aging. An outline of more extensive tests is given.

WELDS. Computing Fillet Weld Stresses, C. H. Jennings. *Welding*, vol. 2, no. 2, Feb. 1931, pp. 101–104, 8 figs. Development of three methods for computing fillet weld stresses—the conventional method, principal stress method, and resultant force method. Tensile test results are compared with calculated stresses in different sized welds.

Strength of Welded Shelf-Angle Connections, J. H. Edwards, H. L. Whittemore, and A. H. Stang. *U.S. Bur. Standards—Jl. Research*, vol. 5, no. 4, Oct. 1930, pp. 781–792, 5 figs. Shelf angles for transferring loads from the floor beams to the columns in steel-frame buildings were arc-welded to H-section steel columns; specimens were tested to destruction in 10,000,000-lb. testing machine of National Bureau of Standards.

The Strength of Electric Arc Welds in Structural Mild Steel, R. R. Blackwood. *Commonwealth Engr. (Melbourne)*, vol. 18, no. 2, Sept. 1, 1930, pp. 50–55, 5 figs. Report on preliminary tests of side- and end-fillet welds under axial loads, carried out at Engineering School of Melbourne University, during 1928–1930. (To be continued.)

Tests on Electric Arc-Welded Lap Joints, R. P. Davis and L. V. Carpenter. *W.Va. Univ. College Eng.—Research Bul.*, no. 7, series 16, no. 2, Nov. 1930, 16 pp., 2 figs. Investigation to check work of other investigators and to obtain further information and data upon which safe unit working stresses for design of lap-welded plates can be based when using arc type of welding.

PORTS AND MARITIME STRUCTURES

BROOKLYN, N.Y. The Brooklyn Waterfront, A. B. Hager. *Brooklyn Engrs.' Club—Proc.*, vol. 29, part 1, Oct. 1930, pp. 8–26, 13 figs. Description of basins and port facilities accompanied by aerial photographs.

CONSTRUCTION, HALIFAX, N.S. New Ocean Terminal at Halifax, N. S. *Can. Engr.*, vol. 60, no. 6, Feb. 10, 1931, pp. 22–23, 3 figs. Construction and sinking of concrete cribs for pier which will cost $3,500,000.

NEW YORK. The Port of New York. *Dock and Harbor Authority (Lond.)*, vol. 11, no. 122, Dec. 1930, pp. 61–62. Appropriations for harbor improvements; value of foreign commerce at port; grain exports; domestic commerce; service at port; State Barge Canal; steamship passenger traffic via port; vessel movements in foreign trade; steamship sailings.

PIERS, FLOORS. Novel Floor Construction Feature of New Pier. *Ry. Age*, vol. 90, no. 7, Feb. 14, 1931, pp. 358–361, 7 figs. Erie makes first use of new design to permit building of three-story structure on foundation designed for two stories. The new piers are on the New Jersey side of the Hudson River, directly opposite New York City, one within the limits of Jersey City, and the other in Weehawken. Typical section through pier; details of floor design and advantages.

SHORE PROTECTION. Shore Protection. *Contract Rec. (Toronto)*, vol. 44, no. 51, Dec. 17, 1930, pp. 1553–1554. How concrete should be used in breakwaters, sea walls, bulkheads, and jetties. (To be continued.)

SOUTHERN UNITED STATES. Southern Port Development, L. Brown. *Mfrs. Rec.*, vol. 99, no. 7, Feb. 12, 1931, pp. 29–34, 11 figs. Brief account of developments of 20 ports from Baltimore, Md., to Corpus Christi, Tex.

WILMINGTON, DEL. Terminal Problems at the Port of Wilmington, C. H. Gant. *World Power*, vol. 19, no. 4, Feb. 1931, pp. 598–606 and (discussion) 606–610. Location of port; creation of port commission; marine terminal; loading and discharging; channel navigation; terminal personnel; industrial tracts; rail rate difficulties; new wharf.

ROADS AND STREETS

BITUMINOUS MATERIALS. The Viscosity of Bituminous Substances, K. A. Hoepfner. *Roads and Road Construction*, vol. 9, no. 97, Jan. 1, 1931, pp. 17–19, 2 figs. Property and importance of viscosity of bituminous substances; solidification point and method for its accurate determination; solidification points of some asphalts determined by finger nail, steel pen, and solid point H-M. (To be continued.)

CONCRETE. Concrete Roads, Past, Present, and Future, J. H. Walker. *Structural Engr.*, vol. 9, no. 2, Feb. 1931, pp. 55–64, 6 figs. General principles of design and construction; disadvantage of joints; interlocked joints; concrete roads in America; maintenance of roads; steel reinforcement; essentials for concrete pavement; "macrete" surface; continuity of pavement; anchorete system.

CONCRETE, CONSTRUCTION. Construction of Reinforced Concrete Roads, W. S. Wilson. *Surveyor*, vol. 79, no. 2035, Jan. 23, 1931, pp. 77–80, 15 figs. Maximum thickness of concrete required; amount and disposition of steel reinforcement; shearing stresses and consideration affecting practical construction.

CONSTRUCTION, TIME STUDY. Grading the Chinook Pass Scenic Highway, Washington, R. W. Edwards and N. L. James. *West. Construction News*, vol. 6, no. 2, Jan. 25, 1931, pp. 26–31, 7 figs. Results of detailed study made by Bureau of Public Roads of drilling and blasting operations on contract for 15.6 miles between Morse and Crystal creeks. General plan of work; equipment and personnel; vertical or down-hole drilling; coyote-hole construction and blasting; power shovel operation; stop watch studies of drilling operation; summary of $1^1/_4$-yd. shovel operations and delays.

CULVERTS, CONCRETE. Field Inspection of Concrete Pipe Culverts, R. W. Crum. *Iowa State College of Agriculture and Mechanic Arts—Official Pub.*, vol. 29, no. 14, Sept. 3, 1930, 32 pp., 3 figs., 12 tables. Report on regular inspection of some 46 culverts, ranging in size from 24 to 66 in. in diam.; records covering life of 22 years; effects of various natural agencies upon life serviceability of concrete pipe culverts; utilization of field inspection data; strength tests; computation diagram for external loads on projecting conduits.

DESIGN, CURVES. A Simple Method of Setting Out a Curve, F. T. Murray. *Roads and Road Construction*, vol. 9, no. 97, Jan. 1, 1931, pp. 15–16, 4 figs. Outline of method simple enough to be used by ordinary foremen and laborers.

DETOURS. Safety and Speed on Detours, V. R. Burton. *Eng. News-Rec.*, vol. 106, no. 1, Jan. 1, 1931, pp. 16–18. Current practice makes modern by-pass "temporary route" instead of slow, unsafe road formerly pictured as "detour"; detour period reduced by planning; special cements speed up repairs; adequate barricades needed.

HIGHWAY ENGINEERING, UNITED STATES. Notable Technical Surveys Presented at A.R.B.A. Convention. *Eng. News-Rec.*, vol. 106, no. 4, Jan. 22, 1931, pp. 155–157. Brief abstracts of papers and committee reports presented at American Road Builders Assn. convention; highway location; low-cost road design and construction; snow removal; airport drainage and surfacing; city paving; contracting problems.

HIGHWAY SYSTEMS, PLANNING. Designing State Highway Systems, T. H. Cutler. *Civil Eng. (N.Y.)*, vol. 1, no. 4, Jan. 1931, pp. 315–318, 7 figs. Missouri method of designing highway systems of state; relationship between traffic density per capita and population per square mile used to determine economic limitation to building of "marginal mile" of highway; "marginal mile" is mile having annual cost equaling annual savings in operation costs to road users; efficiency of road groups in relation to population density; measuring effectiveness of system.

LOW COST. Dane County's Eight Years' Experience with Low-Cost Road Methods, G. E. Martin. *Pub. Works*, vol. 62, no. 2, Feb. 1931, p. 21, 3 figs. Consulting engineer of General Tarvia Dept., Barrett Co., discusses low cost gravel-road practice in vicinity of Madison, Wis., with special reference to use of Tarvia products.

PAVEMENTS, CONSTRUCTION. Current Practice in Building Permanent Pavements, H. A. Lumsden. *Contract Rec.*, vol. 45, no. 8, Feb. 25, 1931, pp. 184–186, 4 figs. Methods in general use for constructing concrete and asphaltic types of roads; bituminous penetration pavements; asphaltic macadam, mixed macadam, black base, retread.

SEWERAGE AND SEWAGE DISPOSAL

ACTIVATED SLUDGE. The Mechanism of the Activated Sludge Process of Sewage Disposal, E. C. C. Baly. *Chem. and Industry*, vol. 50, no. 3, Jan. 16, 1931, pp. 23T–26T. Sewage colloids have iso-electric point at pH 4.6 and this point is shifted toward side of greater pH in presence of electrolytes. Colloids in ordinary sewage with pH 7.4 are electro-negative. Bacteria of sewage carry electro-negative charge, and when their concentration is sufficient they are flocculated by electro-positive colloids. It has been suggested that success of activated-sludge process is due to much enhanced charge on bacteria when in their state of maximum activity.

FLY CONTROL. Experiments on the Destruction of the Filter Fly (Psychoda), W. D. Scouller and H. H. Goldthorpe. *Surveyor*, vol. 79, no. 2037, Feb. 6, 1931, pp. 219–220. Report on experimental studies made at Huddersfield on creosote oil and ortho-dichlorbenzene emulsion and the comparison of the two tests of the emulsions. Before Assn. Mgrs. Sewage Disposal Works.

FOAMING. Foaming Prevention in Imhoff Tanks, G. S. Russell. *Can. Engr.*, vol. 60, no. 4, Jan. 27, 1931, pp. 17–18. Indexed in Engineering Index 1930, from *Water Works and Sewerage*, Nov. 1930.

GERMANY. Sewage and River Purification Experiences, Imhoff. *Surveyor*, vol. 79, no. 2034, Jan. 16, 1931, pp. 57–58. English abstract of annual report of Ruhrverband on sewage purification and river improvement, self purification of river water and standard of self-purification.

GREAT BRITAIN. Recent Methods of Sewage Treatment, W. Butler. *Surveyor*, vol. 79, no. 2038, Feb. 13, 1931, p. 247. Abstract of paper and discussion on experimental work recently carried out at southern outfall of London sewerage system. Paddlewheel channel, plus air blowing, would be most suitable for solution of London problem. Two-story channel through which sewage is propelled and into which air is blown, possesses particular advantages. Diffused air is used for reactivation of sludge.

HAMILTON, N.Y. Sewer System and Disposal Plant at Hamilton, N.Y., H. W. Taylor. *Am. City*, vol. 44, no. 1, Jan. 1931, pp. 106–108, 3 figs. Construction of sewers; description of disposal plant consisting of pumping station for all sewage, two preliminary settling tanks, sludge-digestion tank with floating cover, sprinkling filter with Barns glass cover, open final settling tank, sludge beds, and short submerged outfall sewer.

IMHOFF TANKS, LIME TREATMENT. The Benefits of Liming an Imhoff Tank, H. C. Brill and C. W. Kreger. *Water Works and Sewerage*, vol. 77, no. 12, Dec. 1930, pp. 415–416, 4 figs. Foaming Imhoff tank handling domestic sewage and lime treatment is discussed; frequent pH determinations of sludge from Imhoff tank to ascertain its effectiveness are recommended; pH values at different depths in Imhoff tank; sludge pH is best indication of effective working. Bibliography.

INFILTRATION. Sewer Infiltration Control at Miami, J. E. Jewett. *Eng. News-Rec.*, vol. 106, no. 4, Jan. 22, 1931, pp. 150–152, 3 figs. Multiple pumping dictates rigid specifications, special joints and other details and minimum leakage tests; chart of ex-filtration in thousands of gallons per mile per 24 hrs. for use in sewer testing; details of pick hole for lifting sewer manhole cover, cast-iron brace and wedge for wye branch stopper, etc.; cement grout joint eliminates most of infiltration troubles; ex-filtration test is reasonable index of watertightness under local conditions found in Miami.

PLANTS, AURORA, ILL. A New Development in Sewage Treatment Plant Design, L. R. Howson. *Am. City*, vol. 44, no. 2, Feb. 1931,

pp. 81–85, 6 figs. Description of new sewage treatment plant at Aurora, Ill., serving population of 67,000, which unites modern architecture compact plant layout, centralization of plant operations, utilization of mechanical appliances for distasteful operations frequently neglected if done by hand, and collection and utilization of gas for heating buildings and sludge.

SEWERS, CONSTRUCTION. Continuous Operation Speeds Work on Segmental Block Sewer. *Eng. News-Rec.*, vol. 106, no. 5, Jan. 29, 1931, pp. 197–198, 4 figs. Application of modern mass-production methods to construction of segmental clayblock stormwater drain in Wilmette, Ill., resulted in progress of 150 ft. per day. Main trunk line varies from 102 to 72 in. internal diameter; invert blocks are laid in 30-ft. sections, and backfill is carried along with progress of excavation and masonry work.

SEWERS, NEW JERSEY. New Jersey Joint Outlet Sewer Being Duplicated, E. S. Rankin. *Eng. News-Rec.*, vol. 106, no. 7, Feb. 12, 1931, p. 288. Secretary Joint Meeting, in the matter of an outlet sewer for certain municipalities in Essex and Union Counties, N.J., discusses history and organization of body for construction of 16 miles of sewer and disposal works by 11 municipalities.

SLUDGE BEDS. Glass Covered Sludge Beds, A. E. Kimberly. *Water Works and Sewerage*, vol. 77, no. 12, Dec. 1930, pp. 423–429, 7 figs. Sludge disposal as frequent source of odors; sludge drying under glass; advantages; sludge bed areas; sludge bed area requirements of New York Department of Health; interpretation of experience at Marion, O.; sludge volumes; dry solids and volume relation in sewage sludge; economic aspects.

STORM, CONSTRUCTION. Methods and Cost of Constructing Corrugated Iron Pipe Storm Sewers, T. J. Morrison. *Water Works and Sewerage*, vol. 78, no. 2, Feb. 1931, pp. 30–32, 3 figs. Methods used in construction of drainage system of Whitehaven Memorial Park, Rochester, N.Y. It was designed to meet varied conditions. Armco paved invert pipe and vitrified tile pipe were used in construction of the main sewer, 3,173 ft. long. Costs.

STREETS, DRAINAGE. Unique Street Intersection Drainage System Employed by City of Berkeley, R. T. Reinhardt. *West. City*, vol. 7, no. 2, Feb. 1931, pp. 32 and 55 Rapid installation of underground pipe structures and replacement of pavements involve use of inlets and outlets, connected by full circle corrugated iron pipe and constructed so as to offer no impediments to traffic. Steel bar gratings cover catch basins, inlets and outlets are built into curbs and covered with steel sidewalk plates, and spiral welded pipe is used.

TUNNELS

CONCRETE LINING. Mast Hoist Put to Unusual Use on Tunnel Job. *Constructor*, vol. 13, no. 2, Feb. 1931, p. 39, 1 fig. Description of mast hoist plant with two 28-S mixers made in connection with pouring concrete lining for Figueroa Street Tunnel in Los Angeles, Calif. This device enabled contractor to start pouring concrete while still carrying on excavation of other parts of tunnel.

RAILROAD, MAINTENANCE AND REPAIR. How the Baltimore & Ohio Lines Tunnel. *Ry. Eng. and Maintenance*, vol. 27, no. 2, Feb. 1931, pp. 128–133, 9 figs. Confronted with problem of maintaining tunnels through materials that differ widely in stability on lines of varying density of traffic, the Baltimore and Ohio Railway has developed practices that are worthy of wider application. Maintenance and repair work in Sand Run and Fairmont Park Tunnels is outlined.

VEHICULAR, VENTILATION. Ventilation for International Tunnel, R. S. Wood. *Nat. Engr.*, vol. 35, no. 1, Jan. 1931, pp. 20–21, 2 figs. Design and operating features of ventilating system installed in International Tunnel connecting Detroit, Mich., and Windsor, Canada. There is a complete air change every 90 seconds. Three methods were employed in the construction.

WATER SUPPLY, DEARBORN, MICH. Driving a 2-Mile, 21-Ft. Tunnel at Dearborn. *Mich. Eng. and Contracting*, vol. 70, no. 2, Feb. 1931. pp. 35–38, 5 figs. Methods used in constructing water supply bore for furnishing 913,600,000 gal. daily to Rouge plant of Ford Motor Co.

Driving a 2-Mile Water Tunnel with a Capacity of Nearly One Billion Gallons Daily. *Contractors and Engrs. Monthly*, vol. 22, no. 2, Feb. 1931, pp. 71–76, 6 figs. Construction of new power unit at River Rouge Plant of Ford Motor Company at Dearborn, Mich., which necessitated a two-mile intake tunnel, which was a true cylinder with inside diameter of 15 ft. and outside diameter of 21 ft., located 60 ft. below the surface of the ground.

WATER PIPE LINES

CONSTRUCTION. Placing a Water Main up Slope of Lookout Mountain. *Water Works and Eng.*, vol. 84, no. 2, Jan. 28, 1931, p. 108, 2 figs. Construction of new 8-in. main, 3,924 ft. long, to base of Lookout Mountain standpipe, 1,534 ft. above Chattanooga, using a specially designed tool to carry pipe. Work was difficult because of fallen trees, boulders, and danger of falling rocks. Reprinted from *Water*.

SUBAQUEOUS. Submarine Pipe-Line Between Portland, Me., and Great Diamond Island, H. U. Fuller. *New England Water Works Assn.—Jl.*, vol. 44, no. 4, Dec. 1930, pp. 479–483, 1 fig. Report on raising and re-laying of old leaky pipe line in Casco Bay, Portland, Me., and of laying 12-in. main, 1,700 ft. long, between mainland and Mackworths Island, and 8-in. main, 6,800 ft. long, between Mackworths Island and Great Diamond Island.

WATER HAMMER. What to Do When Hammer Is Encountered, L. H. Kessler and H. Pommerenck. *Domestic Eng. (Chicago)*, vol. 134, no. 3, Feb. 7, 1931, pp. 65–66, 68, 71–72, and 74, 6 figs. Results of studies and origina investigations dealing with causes and remedies of water hammer, a description of the apparatus and method of testing, and curves illustrating test results.

WATER PUMPING PLANTS

PLANTS, CHICAGO. An Unusual Water Supply Problem, L. J. Hotchkiss. *Military Engr.*, vol. 23, no. 127, Jan.-Feb., 1931, pp. 15–17, 3 figs. Description of new pumping plant of Corn Products Refining Co.; concrete-lined shaft, 10 ft. inside diam., depth 360 ft.; concrete-lined pump chamber, 38 ft. by 43 ft. by 11 ft.; 3,935 ft. of gunite-lined tunnels, and connections with 8 existing wells; method of construction.

WATER RESOURCES

NEW YORK. Special Master Recommends Limited Division of Delaware River Water by New York City. *Eng. News-Rec.*, vol. 106, no. 7, Feb. 12, 1931, pp. 284–286, 1 fig. Equitable apportionment among three states is advised with New York's share cut to minimize damage from reduced flow. Details of plan and map of present and proposed sources of water for New York City are included.

SUPPLYING NEW YORK. The Recent Drought and New York State Water Supplies, E. Devendorf. *Am. Water Works Assn.—Jl.*, vol. 23, no. 1, Jan. 1931, pp. 69–76. Many of the public water supplies in the state have been affected to varying degrees by drought, yet the number of supplies seriously depleted has been relatively small. The normal annual rainfall in New York State and the effect of drought are shown.

WATER TREATMENT

CHLORINATION. Efficiency of Chlorination at Chicago, H. H. Gerstein. *Am. Water Works Assn.—Jl.*, vol. 23, no. 1, Jan. 1931, pp. 53–62, 1 fig. Indexed in Engineering Index 1930, from *Water Works and Sewerage*, Aug. 1930.

CHLORINATION, PRECHLORINATION. Prechlorination in Relation to the Efficiency of Water Filtration Processes, H. W. Streeter and C. T. Wright. *Am. Water Works Assn.—Jl.*, vol. 23, no. 1, Jan. 1931, pp. 22–49 and (discussion) 49–52, 12 figs. Report on 16 months tests at experimental plant of rapid sand type at Cincinnati, showing monthly numbers of bacteria and amounts of residual chlorine at various stages of treatment, with and without raw water prechlorination, monthly B. coli indices, and the relations between numbers of bacteria in raw water and corresponding numbers in effluents from various states of treatment, with and without prechlorination; also, periods of service of filters receiving prechlorinated and nonprechlorinated water.

FILTRATION PLANTS. Design of Mixing Basins, J. R. Baylis. *Water Works and Sewerage*, vol. 78, no. 1, Jan. 1931, pp. 13–20, 8 figs. List of larger rapid-sand filtration plants, giving type of mixing basin, time of mixing, and velocity of water; arrangement of baffles, columns, and braces at mixing basin, Baltimore; plans and sections of typical vertical and horizontal mixing basins; computed and measured loss of head through Baltimore mixing basin; velocity and loss of head in horizontal baffled basin; mechanical mixing basins; spiral inward flow; cost of power for agitation in mechanical mixing basin; other types of mixing basins. Bibliography.

FILTRATION PLANTS, TESTING. Test Procedure at Small Water Works Filter Plants, J. M. Jester. *Water Works Eng.*, vol. 83, no. 27, Dec. 31, 1930, pp. 1912–1913. Necessity for care in making such tests; hydrogen-ion concentration tests for residential chlorine; tastes and odors. From paper read before Maryland-Delaware Water and Sewerage Assn.

PLANT, CEDAR RAPIDS, IOWA. New Water Softening and Filtration Plant of Cedar Rapids, Iowa, L. R. Howson. *Water Works and Sewerage*, vol. 77, no. 12, Dec. 1930, pp. 411–414, 3 figs. Description of water treatment plant designed to serve expected population of 75,000 in 1940; aeration; chemical facilities; mixing facilities; clarifier and settling basin; series vs. parallel operation; carbonation; high lift pumping equipment.

PURIFICATION, OTTAWA, ONT. Water Purification Plant at Ottawa, Ont., A. D. Stalker. *Can. Engr.*, vol. 60, no. 6, Feb. 10, 1931, pp. 15–19 and 65, 7 figs. Design and construction of plant which will have initial capacity of 35 million gal. and ultimately of 84 million gal.

SOFTENING. Advantages of Water Softening for Small Cities, C. H. Curre. *Water Works Eng.*, vol. 83, no. 27, Dec. 31, 1930, p. 1918. Reasons for undesirability of hard water; saving that can be effected by softening water; advantages of municipal softening; two general methods of water softening. Abstract of paper read before Iowa Water Works Conference, Iowa City, Ia.

TASTE AND ODOR REMOVAL. Taste Elimination with Powdered Activated Carbon, E. A. Sterns. *Water Works and Sewerage*, vol. 78, no. 1, Jan. 1931, pp. 11–12, 2 figs. Experiments and results obtained at Hamburg, N.Y., showing a special feeder developed for application of activated carbon, application of powdered activated carbon, and the method of operation.

WATER WORKS ENGINEERING

CALIFORNIA SYSTEM. The New Water Supply of the East Bay Municipal Utility District, F. W. Hanna. *Am. Water Works Assn.—Jl.*, vol. 23, no. [illegible], Jan. 1931, pp. 14–21. Principal features of new water-supply system, including curved gravity dam, 357 ft. high, and 95-mile aqueduct comprising 9.3 miles of tunnels.

CEDAR RAPIDS, IOWA. A Water Plant to Include Carbonation, Softening, and Filtration, L. R. Howson. *Water Works Eng.*, vol. 84, no. 3, Feb. 11, 1931, pp. 157–158 and 170–172, 5 figs. Description of new water works of Cedar Rapids, Ia., for estimated population of 75,000 in 1940 with details of low lift station, chemical facilities, clarifier, and settling basin.

EARTHQUAKES. Disaster Preparedness Plans for Water Works, G. W. Pracy. *Water Works and Sewage*, vol. 78, no. 2, Feb. 1931, pp. 43–44, 1 fig. Precautions that should be taken when designing and constructing water works in places subject to earthquakes. Before Am. Water Works Assn., indexed in Engineering Index 1930 from their Journal, Sept. 1930.

ENGINEERING. The Institution of Water Engineers. *Engineering*, vol. 13, no. 3393, Jan. 23, 1931, pp. 125–126. Brief review of following papers, read on Dec. 15, 1930: Reliability of Rainfall over British Isles, J. Glasspoole; Kempton Park Primary Filters of Metropolitan Water Board, S. Walker; Water Mains, H. J. F. Gourley; Hollerith System of Tabulation, G. O. Ritchie.

INFILTRATION GALLERIES. Water Supply Increased by Use of Infiltration Gallery, A. A. Weiland. *Water Works and Sewerage*, vol. 78, no. 1, Jan. 1931, pp. 1–2, 5 figs. Castle Rock, Douglas County, Colo., secured additional water by constructing 2,800-ft. perforated collection line, for underground flow in gravel bed.

MODERN AQUEDUCT. Liverpool Water Supply. *Civil Eng. (Lond.)*, vol. 25, no. 8, Jan. 1931, pp. 411–414, 5 figs. History of Liverpool water supply since 1847 includes a description of the present system, recent extensions, and improvements, the new Aber tunnel, which will have a total length of 10,000 ft., and the new aqueduct, 68 miles long, which will consist of four 42-in. cast iron pipes.

RESERVOIR, GREAT BRITAIN. Baddingsgill Reservoir—Lyne Scheme. *Water and Water Eng.*, vol. 33, no. 385, Jan. 20, 1931, pp. 16–19, 11 figs. Description of water supply system, consisting of storage reservoir having capacity of 495 million gal. and maximum depth of 78 ft., from which 24 in.-diam. cast iron pipe conveys water 18 miles to concrete service tank holding 1 million gal. From this tank, 15-in. pipe and 12-in. pipe are joined up to existing distribution mains.